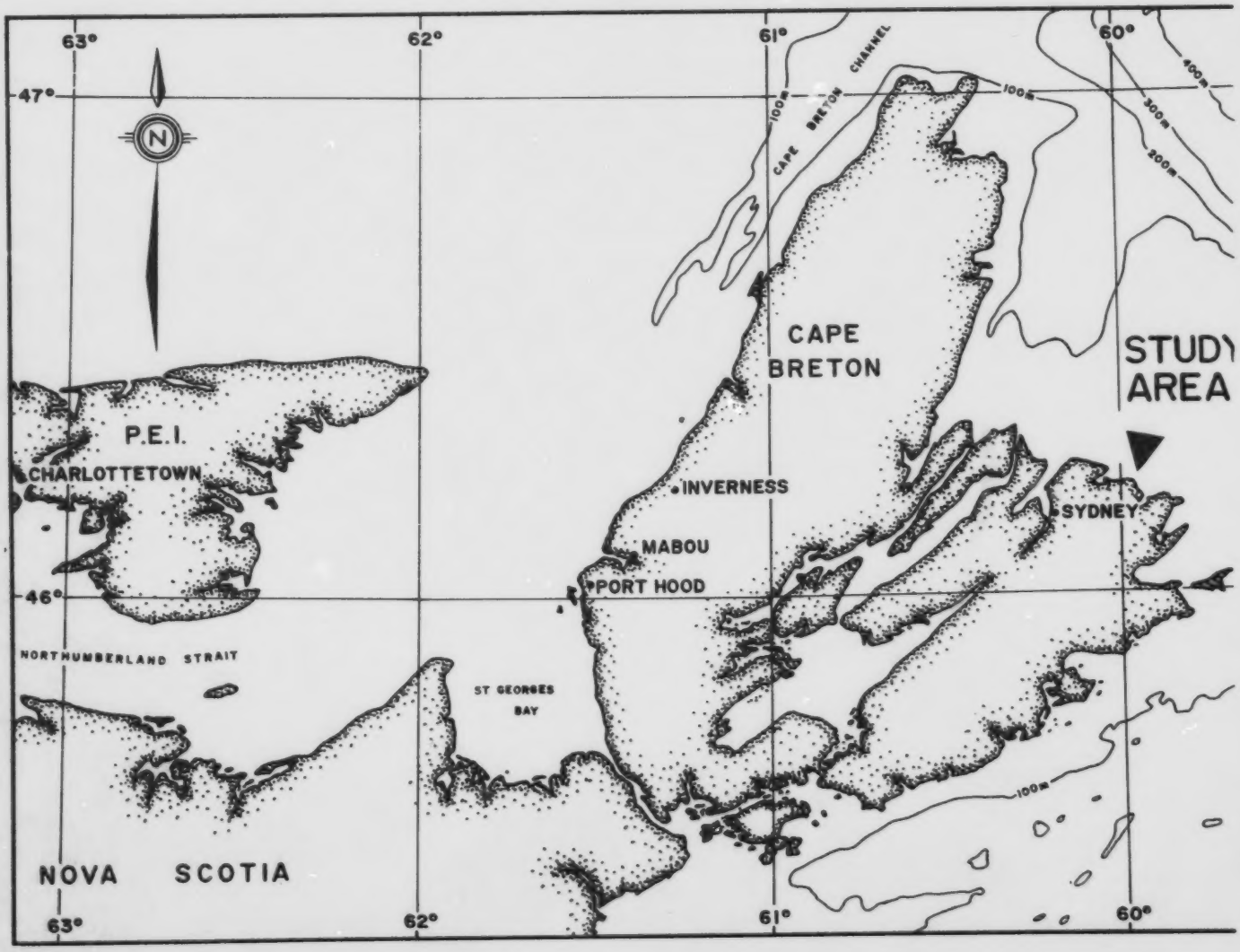
Cape Breton Coal Research Laboratory

Seafloor Topography
Over New Phalen Colliery, Phase 2
Sydney Coalfield
Cape Breton Island, Nova Scotia

June
1989

Text and Enclosures



McGregor GeoScience Limited

Halifax Nova Scotia Canada

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SEAFLOOR TOPOGRAPHY OVER THE PHALEN COLLIERY, PHASE 2 SYDNEY COALFIELD CAPE BRETON, NOVA SCOTIA

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MICROMEDIA

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EXECUTIVE SUMMARY

A 67 line-kilometre grid of marine, high resolution echosounder and subbottom profiler data was acquired over the Cape Breton Development Corporation's Phalen Colliery, off New Waterford, Nova Scotia. The survey was conducted in August of 1988 for the Cape Breton Coal Research Laboratory of CANMET (EMR). The survey was the second phase of a multi-year program designed to evaluate mining-induced seafloor subsidence by comparing pre-mining seafloor profiles with post-mining seafloor profiles.

Subbottom profiler data indicates that bedrock outcrops at the seafloor above most of the western and eastern Phalen Colliery workings.

The tracks of survey lines and the echosounder profiles acquired along these tracks were digitized. Using the digital data, individual line, plan and profile drawings were produced. These profiles detail the seafloor topography at the time of surveying. The profiles and plans are stored as AutoCad (ACAD) drawing files. This software permits superposition of the 1988 results with earlier 1987 ACAD diagrams. The superposition of future seafloor topographic profile information with these ACAD drawings is intended to further define seafloor subsidence.

It is anticipated that with the recording and display scales employed, subsidence of greater than 0.25 m, may be detectable. The survey conducted in 1988 actually includes five lines beneath which mining occured after the 1987 survey and prior to the 1988 resurvey. These lines represent the first opportunity to compare pre- and post-mining profiles for purposes of detecting subsidence profiles. Profiles of Lines 04, 05, 06, 13 and 14 display apparent subsidence.

SOMMAIRE EXÉCUTIF

Soixante-sept (67) kilomètres de données géophysiques marines et de données d'écho-sondeur à haute résolution ont été acquises dans un quadrillage de tracés au-dessus du site de la Mine de Houille Phallen, appartenant à la Corporation de Dévelopement du Cap Breton et située près de New Waterford, Nouvelle-Écosse. Ce levé a été mené durant le mois de août 1988, dans l'intérêt du Laboratoire de Recherche du Charbon du Cap Breton de CANMET (EMR). Il constitue la seconde étape d'un programme polyphasé ayant comme but l'évaluation de la subsidence du fond marin induite par les travaux miniers, et ce, en comparant les profiles du fond marin pré- et post- miniers.

Les données géophysiques indiquent que le substratum rocheux affleure au fond marin au-dessus d'une grande partie de l'ouest et de l'est de la mine de Houille Phalen.

Le tracé du levé ainsi que les profils des données de l'écho-sondeur acquis au long de ce tracés ont été numerisés. Utilisant les données numerisées, des panneaux de tracé individuel, de plan, et de profil ont été produits. Ces panneaux détaillent la topographie du fond marin au moment du levé. Chacun de ces panneaux et profils se trouvent sous la forme de fichiers illustrés dans le logiciel AUTOCAD (ACAD). Ce logiciel permet la superposition des résultats de 1988 sur les diagrammes ACAD de 1987. La superposition de profil topographique de fond marin futur

et de ces tracés ACAD nous aidera à mieux définir la subsidence du fond marin.

Il est prévu qu'avec les échelles d'enregistrement et de présentation employées, une subsidence de plus de 0,25 m pourrait être perçue. Le levé mené en 1988 inclut cinq lignes sous lequel l'extraction minière eu lieu après le levé de 1987 et avant le relevé de 1988. Ces lignes représentent la première opportunité pour comparer les profils pré- et post- miniers dans le buts de détecter des profils de subsidence. Les lignes de profils 04, 05, 06, 13, et 14 montrent une subsidence apparente.

INTRODUCTION

A 67 line-kilometer grid of marine high resolution echosounder and subbottom profiler data was acquired over the Cape Breton Development Corporations's Phalen Colliery, near New Waterford, Nova Scotia (Figure 1). The survey was conducted within the period August 16-22, 1988 for the Cape Breton Coal Research Laboratory of CANMET (EMR) with Dr. Tim Aston, the Scientific Authority. The survey was the second phase of a multi-year program designed to evaluate mining-induced seafloor subsidence by comparing pre-mining seafloor profiles with post-mining seafloor profiles. Figures 2a, 2b and 2c display the grid of bathymetric profile lines acquired in 1988 and the location of the existing or planned Phalen panels. Detailed track plots are presented as Enclosures 1, 2 and 4. The principal survey area was above the West Phalen No. 1, 2 and 3 and East Phalen No. 1, 2, 3, 4 and 5 longwall panels. The profiles collected in this survey detail the seafloor topography as of August, 1988 along the reference profile lines. The same lines will be run after longwall mine advancement. Some of the acquired profiles are coincident with lines run in 1987. These permit observation of the degree of repeatability. Several such lines also coincide with currently active mine workings and permit the first comparison of pre- and post-mining seafloor profiles. Changes in the seafloor topography pre- and post-mining will provide a measure of mining-induced, seafloor subsidence.

This report describes the data collected, its accuracy and the methodology used to process and analyse it. The field work aspect of this project is described in summary in Section 1 and in detail in reports on operations, survey systems, personnel and navigation, included as Appendices 1 through 4 respectively. A data inventory and quality summary is given in Appendix 5.

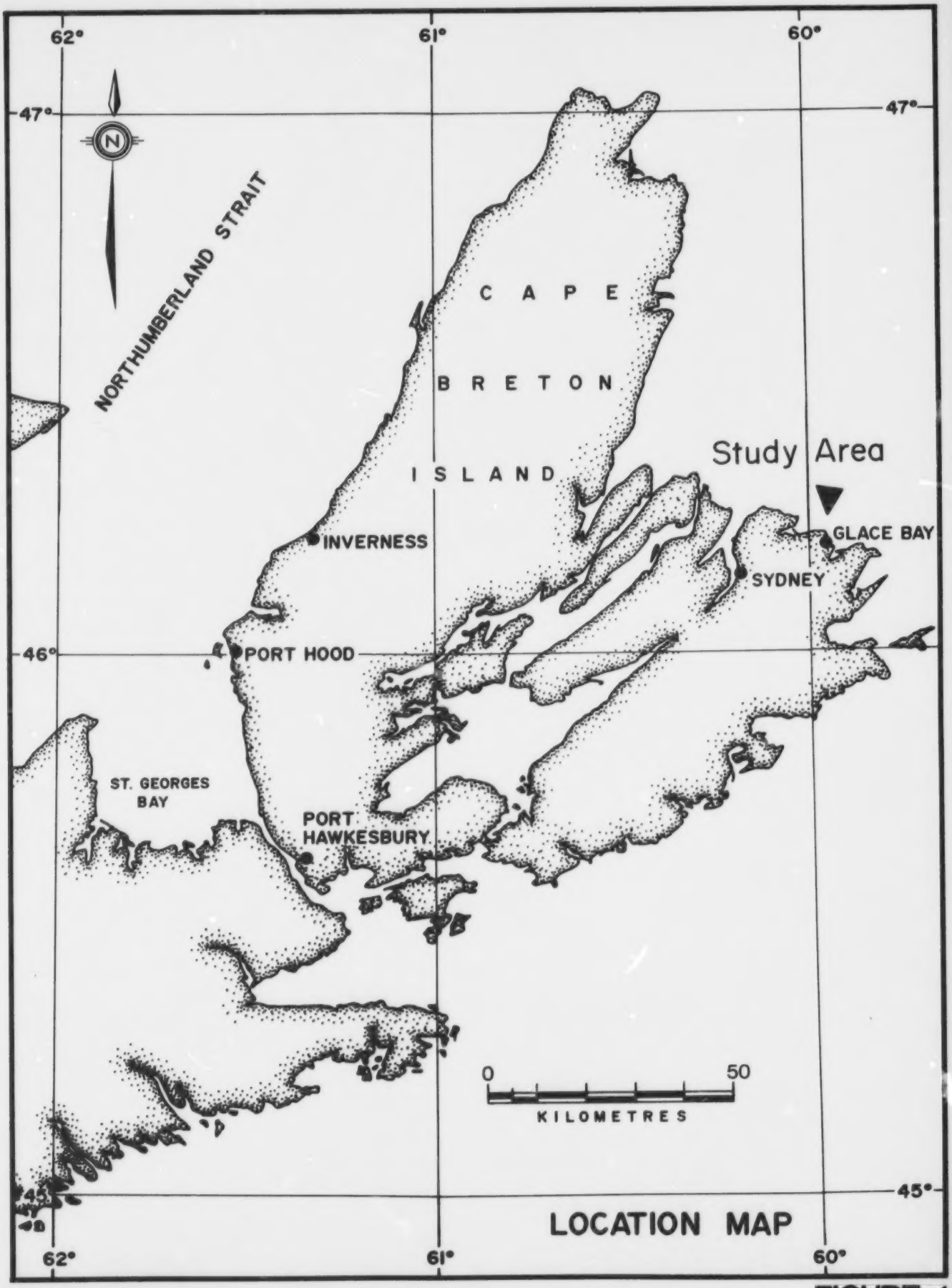
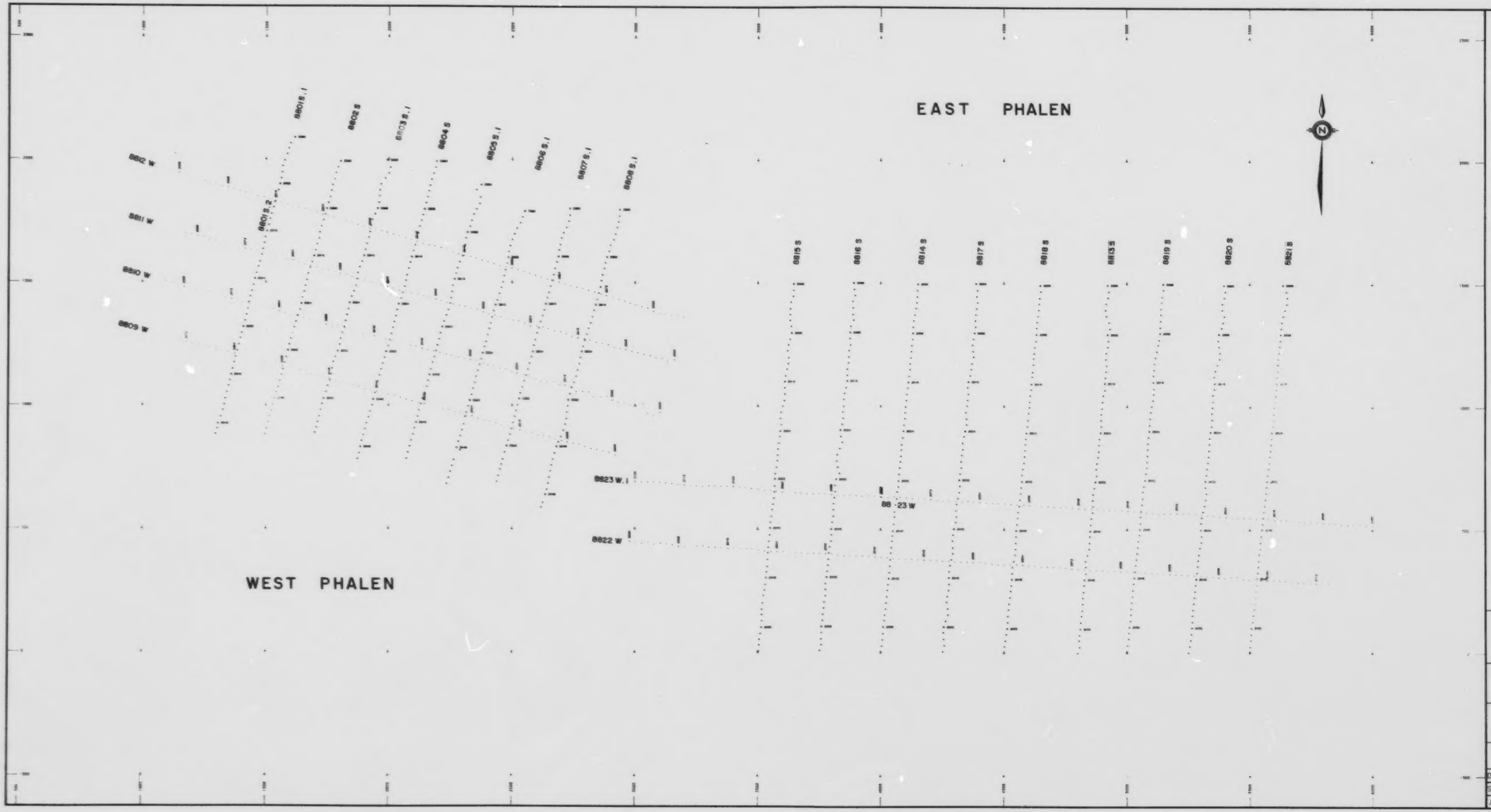

62°
61°
60°
47°
47°
N
NORTHUMBERLAND STRAIT
CAPE
BRETON
ISLAND
Study Area
INVERNESS
GLACE BAY
SYDNEY
46°
PORT HOOD
ST. GEORGES
BAY
PORT
HAWKESBURY
0
50
KILOMETRES
45°
45°
LOCATION MAP
62°
61°
60°

FIGURE 1



NOTE

NAVIGATION was ACHIEVED using DEL NORTE EQUIPMENT with SHORE STATIONS INSTALLED on 4 CONTROL POINTS DEFINED on the CSCD LOCAL GRID.

All POSITIONS PLOTTED on this PLAN are REFERRED to the ECHO SOUNDER LOCATION.

This PLAN REPRESENTS the LINES SURVEYED in the SOUTH and WEST DIRECTIONS.

SCALE 1 : 5 000

McGREGOR GEOSCIENCE

HALIFAX , NOVA SCOTIA

CANMET

CAPE BRETON COAL RESEARCH LABORATORY

PHALEN MINES

SUBSIDENCE STUDY – 1988

McELHANNEY SERVICES LTD.

DATE: AUGUST, 1988	
SCALE:	
JOB NO: 8807	ENCLOSURE: 1

FIGURE 2a

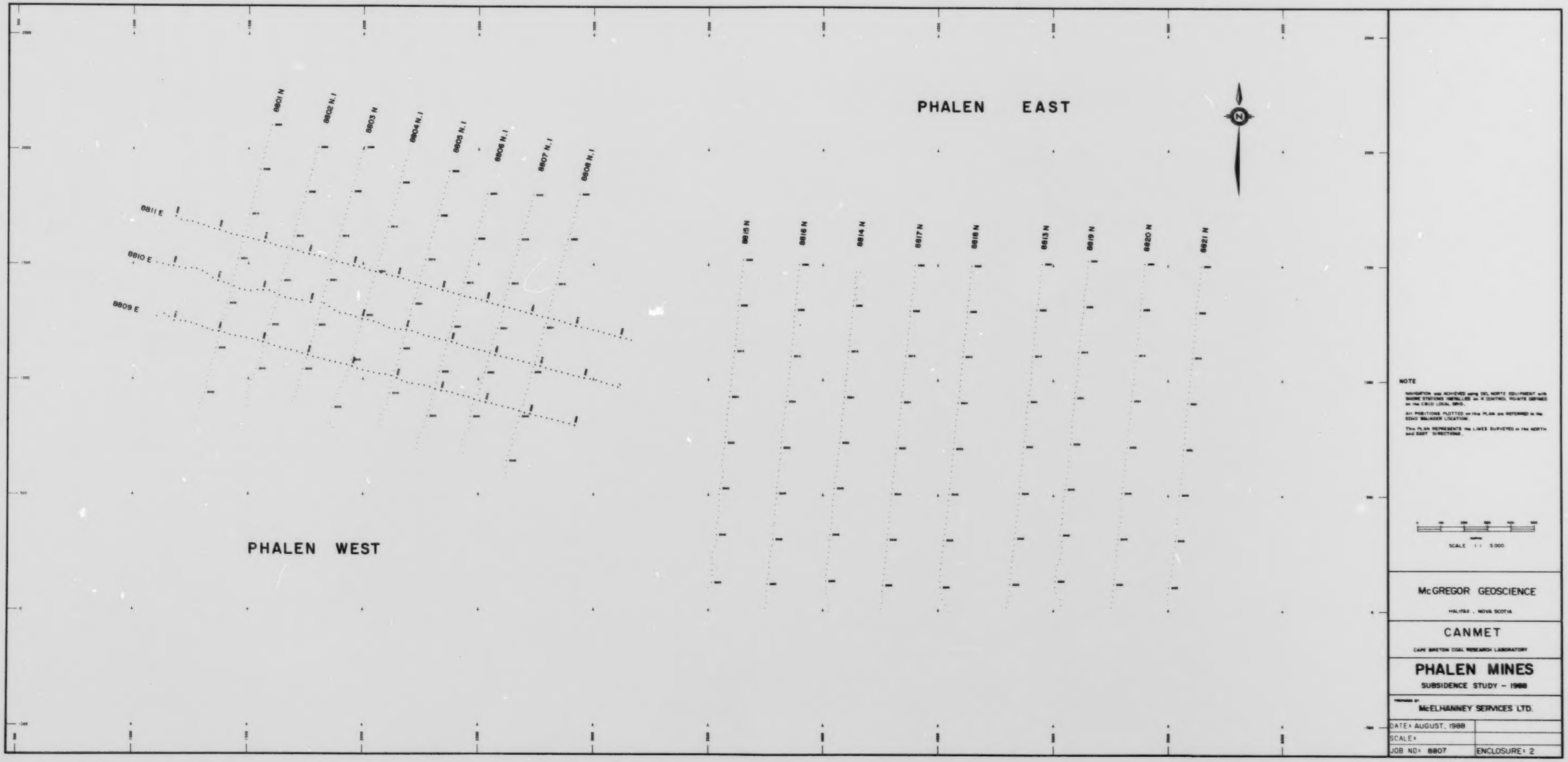

PHALEN EAST
PHALEN WEST
8801 N
8802 N.I
8803 N
8804 N.I
8805 N.I
8806 N.I
8807 N.I
8808 N.I
8811 E
8810 E
8809 E
8815 N
8816 N
8814 N
8817 N
8818 N
8813 N
8819 N
8820 N
8821 N
NOTE
SCALE 1 : 5000
McGREGOR GEOSCIENCE
HALIFAX , NOVA SCOTIA
CANMET
CAPE BRETON COAL RESEARCH LABORATORY
PHALEN MINES
SUBSIDENCE STUDY - 1988
McELHANNEY SERVICES LTD.
DATE: AUGUST, 1988
SCALE:
JOB NO: 8807
ENCLOSURE: 2

FIGURE 2b

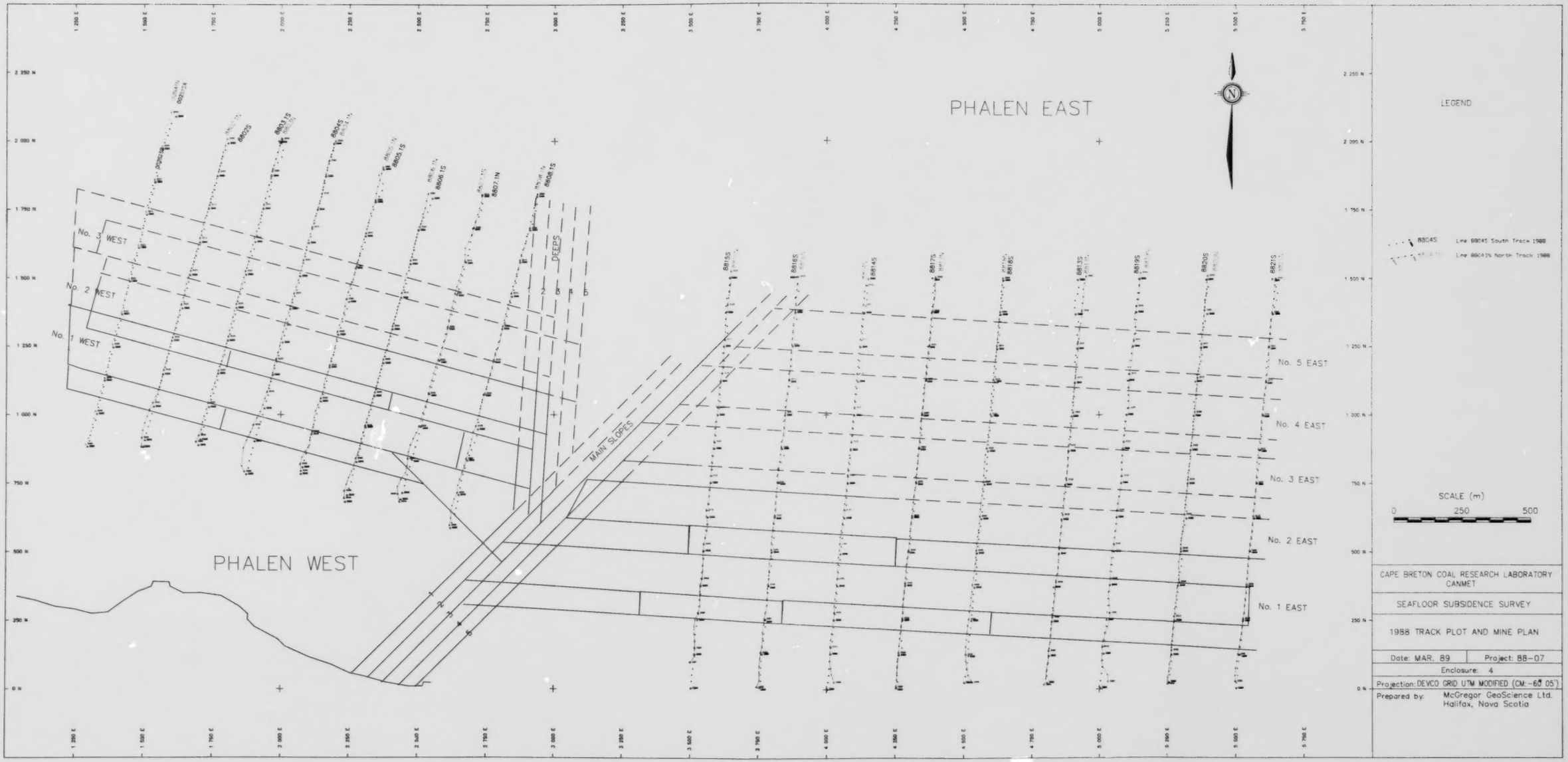

PHALEN EAST
PHALEN WEST
No. 5 EAST
No. 4 EAST
No. 3 EAST
No. 2 EAST
No. 1 EAST
No. 3 WEST
No. 2 WEST
No. 1 WEST
MAIN SLOPES
DEEPS
LEGEND
8804S Line 8804S South Track 1988
Line 8804N North Track 1988
SCALE (m)
0 250 500
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
SEAFLOOR SUBSIDENCE SURVEY
1988 TRACK PLOT AND MINE PLAN
Date: MAR. 89
Project: 88-07
Enclosure: 4
Projection: DEVCO GRID UTM MODIFIED (CM: -60° 05')
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 2c

SECTION 1

THE 1988 FIELD PROGRAM

1.1 Operations Summary

The 1988 field program, completed in August, consisted of running a grid of lines with the control of an electronic navigation system while acquiring echosounder profiles and 3.5 kHz subbottom profile records.

The equipment was comprised of:

a) Krupp Atlas DES0-20 Echosounder

b) ORE Mod 140, 3.5 kHz Subbottom Profiler

c) Del Norte Trisponder System

d) Survey Vessel

a. Echosounder

The Krupp Atlas, Deso 20 echosounding system was installed to acquire high quality bathymetric data. The recording scales were selected to maximize horizontal and vertical resolution of seafloor topography.

The initial calibration of the echosounder to establish transducer depth and speed of sound in seawater was performed at 0845 Hrs. on August 20. The bar check method was used and a water velocity of 1494 metres per second was established and dialed into the sounder.

A transducer depth of 0.5 m was measured and similarly dialed into the recorder for automatic compensation.

Calibration of the echosounder was subsequently rechecked at day end, August 20 and day end, August 21 and the water velocity of 1494 m/sec was confirmed.

As in our previous survey, calm sea conditions proved crucial to acquiring profiles undistorted by sinuous vessel pitch and roll.

The DESO-20 vertical recording scale was 5 metres full scale; i.e., the depth difference between the top and bottom of the recording was 5 metres. The DESO-20 accommodates the changing water depth by manually changing of the phase. When the phase is changed, the recorder immediately prints the phase number (eg. "03") along the lower margin of the recording. The zero as in "03" is centered under the line demarcating the phase change. The zero interrupts any other annotation printing already underway.

The phase numbers and depth ranges for the selected scale are the following:

Phase	Depth Range
00	0.0 - 5.0 m
01	2.5 - 7.5 m
02	5.0 - 10.0 m
03	7.5 - 12.5 m
04	10.0 - 15.0 m
05	12.5 - 17.5 m
06	15.0 - 20.0 m
07	17.5 - 22.5 m
08	20.0 - 25.0 m

b. 3.5 kHz Subbottom Profiles

The ORE 3.5 kHz Profiler confirmed the general absence of sediment in the survey area as no penetration of the seafloor was observed. This indicates that subsidence of the sea floor is unlikely to be obscured by sediment in-filling in the short term.

c. Del Norte Trisponder Positiong System

As in 1987, a Del Norte Trisponder was employed for survey vessel positioning. Similarly, the same four onshore control points were employed for transponders.

Line steering by the skipper and his assistant proved to be excellent. The helmsman was guided by a left-right indicator slaved to the navigation system.

d. Survey Vessel

The survey was conducted from a local fishing vessel, the IDLE OARS II.

1.2 Survey Grid

A survey grid was run overlaying present and future longwall coal mining operations of the West and East Phalen mining areas.

The grid was comprised of the following:

Lines	Trend	Nominal Length	Subtotal
West Phalen			
16 (8 x 2)	N-S	1.25 km	20 km
6 (3 x 2)	E-W	2.0 km	12 km
1 (1 x 1)	E-W	2.0 km	2 km
East Phalen			
18 (9 x 2)	N-S	1.5 km	27 km
2 (2 x 1)	E-W	3.0 km	6 km
		Approximate total:	67 km

SECTION 2

DATA PROCESSING

2.1 Track Plots

The track plots of the survey site are provided as Enclosures 1, 2 and 4. Two separate maps are used to differentiate the repeated lines; Enclosure 1 displays the south- and west-headed lines and Enclosure 2; the north- and east-headed lines. Where lines were repeated to improve the data, the lines are differentiated on the track plots as in the following example:

First run: Line 8804N
Second run: Line 8804N.1

Enclosure 4 combines all 1988 tracks and has the mine plan superimposed.

These track maps were digitized on a digitizing table employing Supertech software to provide files of event mark locations and numbers. Event marks are the points where the echosounder and subbottom profiler records were simultaneously marked and navigation position recorded. The files of event numbers and x and y coordinates, were exported to "AutoCad 10."

2.2 Bathymetric Data Processing

a. Digitization

The echosounding profiles are inherently collected at varying horizontal scale; a function of variations in vessel speed across the ground. To compare replicated profiles it was necessary to re-display the profiles at a common horizontal scale. This was achieved by digitizing the echosounder records and then re-displaying these records as AutoCad drawings with a specified horizontal scale (1:1000). A constant vertical scale of 1:50 was also maintained.

The records were digitized in the point-digitizing mode with point spacing dictated by seafloor complexity and software limitations on the number of points which could be processed. Generally the digitizing increment ranged from 1 to 2 metres horizontal.

Tracings of the echosounder records were made on overlays prior to digitizing. These overlays indicate the position of the seafloor selected by the interpreter, permitting greater efficiency in digitizing, improved quality control and flexibility in editing while avoiding defacement of the original records. The effects of vessel pitch and roll and side echoes were "filtered out" to some extent in this process as the interpreter drew the "best fit" line through the sinuous bottom trace.

b. Tide Correction

The digital files of water depth created in the digitizing process were corrected for tidal variation. The tidal corrections applied were prepared by the Marine Environmental Data Service (MEDS), Ottawa, Ontario and supplied through the Canadian Hydrographic Service, Dartmouth, Nova Scotia. The North Sydney permanent tide gauge was selected because of its close proximity to the survey site. The short time duration over which each line was acquired permitted single bulk shifts in tidal elevation to be applied. The tidal correction calculated at the line's midtime was applied to the entire line. Table 2-2, Appendix 2 provides the tidal information used in these data reductions. The range in tidal elevation during the survey period was approximately 0.61 metres maximum (between high and low tide). Because the typical line duration was only 15 minutes this simple tidal correction is appropriate.

Application of tidal corrections to the water depth data was done on a digital file of water depth and geographic coordinates using Lotus 123 software. The tide-corrected water depth data along with associated x and y geographic co-ordinates were converted to DXF files for export to AutoCad 10.

It is important to note that the hydrographic chart datum to which tidal heights for the area are referenced was elevated by 28 cm in 1988 by the Candian Hydrographic Service upon release of Chart

4266. To make the 1987 and 1988 profiles comparable, the 1987 profiles were uniformly elevated by this 28 cm in AutoCad.

2.3 Plan and Profile Drawing Development

The digitized survey track files were used along with the digitized echosounder profile values to produce composite, plan and profile drawings. These drawings were composed using AutoCad 10. Each finished drawing was subsequently recorded in digital form as an AutoCad drawing file. These drawings, for lines 1 through 8 and 13 through 21 (all north-south lines) display the track plan and superimposed bathymetric profiles. They are plotted at scales of 1:1000 (horizontal) and 1:50 (vertical) and have been deposited with the Scientific Authority. A single, full size panel is included in this report as Enclosure 3 (Plan and Profile, Line 8806). Reduced size versions of lines 1 through 8 and 13 through 21 are included herein as Figures 3 through 19.

The production of these panels is a significant addition to the multi-year project because it establishes all **pre-mining** seafloor topography data in AutoCad drawing files, to which **post-mining** profiles can be added for direct comparison and because it includes the first post-mining profiles. The profile drawing source data, recorded as Lotus 123 files also offers the potential for further editing or smoothing or statistical comparison of profiles.

Copies of AutoCad drawing files, the digital track plot files and digital depth files are stored on MS-DOS compatible diskettes and are deposited with the Scientific Authority.

The upper portion of each drawing displays a rotated plan map of the individual survey lines. The lines were duplicated by running in opposite directions to test the repeatability of vessel guidance, positioning system and echosounder depth measurements and to increase the sampling density.

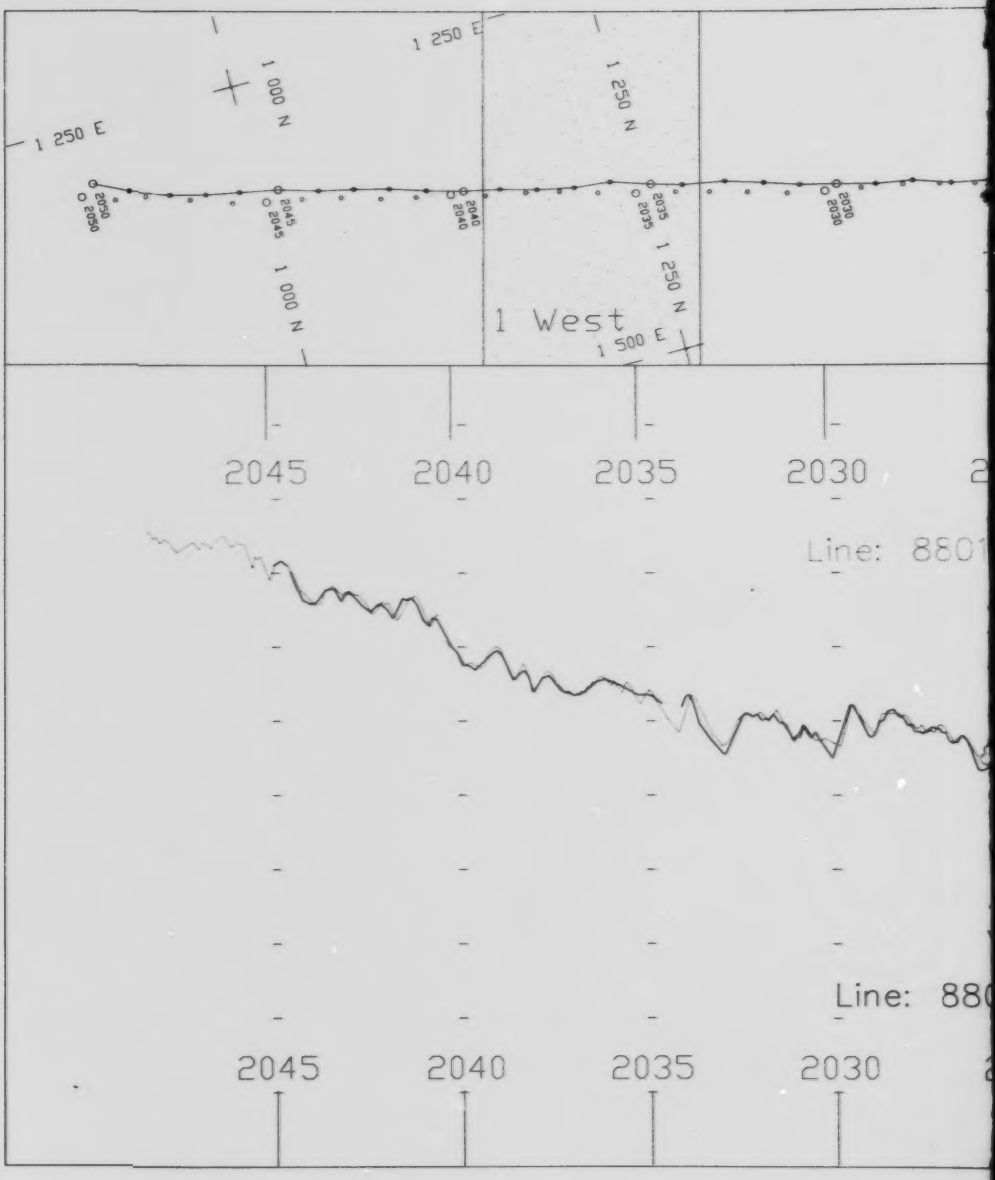
As would be expected, the degree to which repeated line tracks coincide, directly affects the degree of profile correlation. The profiles are generally close to identical in morphology and depth with all major and most minor topographic features preserved. Where lines coincide in plan, depth differences are generally less than 0.2 m. These differences can be accounted for by; variations in the vessel heave (and hence in the degree of smoothing applied to the echosounder profile by the interpreter), the acceptance or rejection of side echoes, inherent inaccuracy in even the highest resolution navigation equipment when installed on a moving and unstable platform, complex microtopographic variations, etc.

The seafloor outcroppings of bedrock, dip in a northward direction. Thus the north-south trending lines represent dip lines and the east-west trending lines represent strike lines.

In contrast to the dip line profile pairs, the strike line profile pairs exhibit a lower degree of repeatability where tracks are close to being superimposed. Comparison of strike line profiles is much more sensitive to line location than dip line profiles. Seafloor topographic ridges trend parallel to strike. Therefore slight offsets in the position of a strike line can make the difference between acquiring a profile along the crest of a ridge or along a flank or trough. A dip line will acquire nearly identical cross sectional profiles of the ridges and troughs whether the lines are superposed or significantly offset. We therefore focused our efforts on the dip lines.

Another factor which causes an apparent mis-match of repeated profiles is the effect of different echosounder record horizontal lengths resulting when lines which deviate from the ideal straight line between start and end points. The echosounder has a pre-selected but constant paper feed rate. Thus a line which deviates substantially from the desired straight line would have a longer record than one that adhered closely to the ideal line. The navigation system ensures that event marks are triggered and positioned at 25 metre intervals along each line. Comparison of

profiles from lines with and without substantial deviation from the ideal line will invariably display some horizontal, along-line offset of topographic features common to both profiles. This may be partially compensated for in AutoCad by shifting one profile (along with its event marks) relative to the other line to produce the best fit for the whole line. This does not effect water depth along a given profile.


1 250 E
1 000 N
1 250 E
1 250 N
2050
2045
2040
2035
2030
1 000 N
1 250 N
1 West
1 500 E
2045
2040
2035
2030
Line: 8801
Line: 880
2045
2040
2035
2030

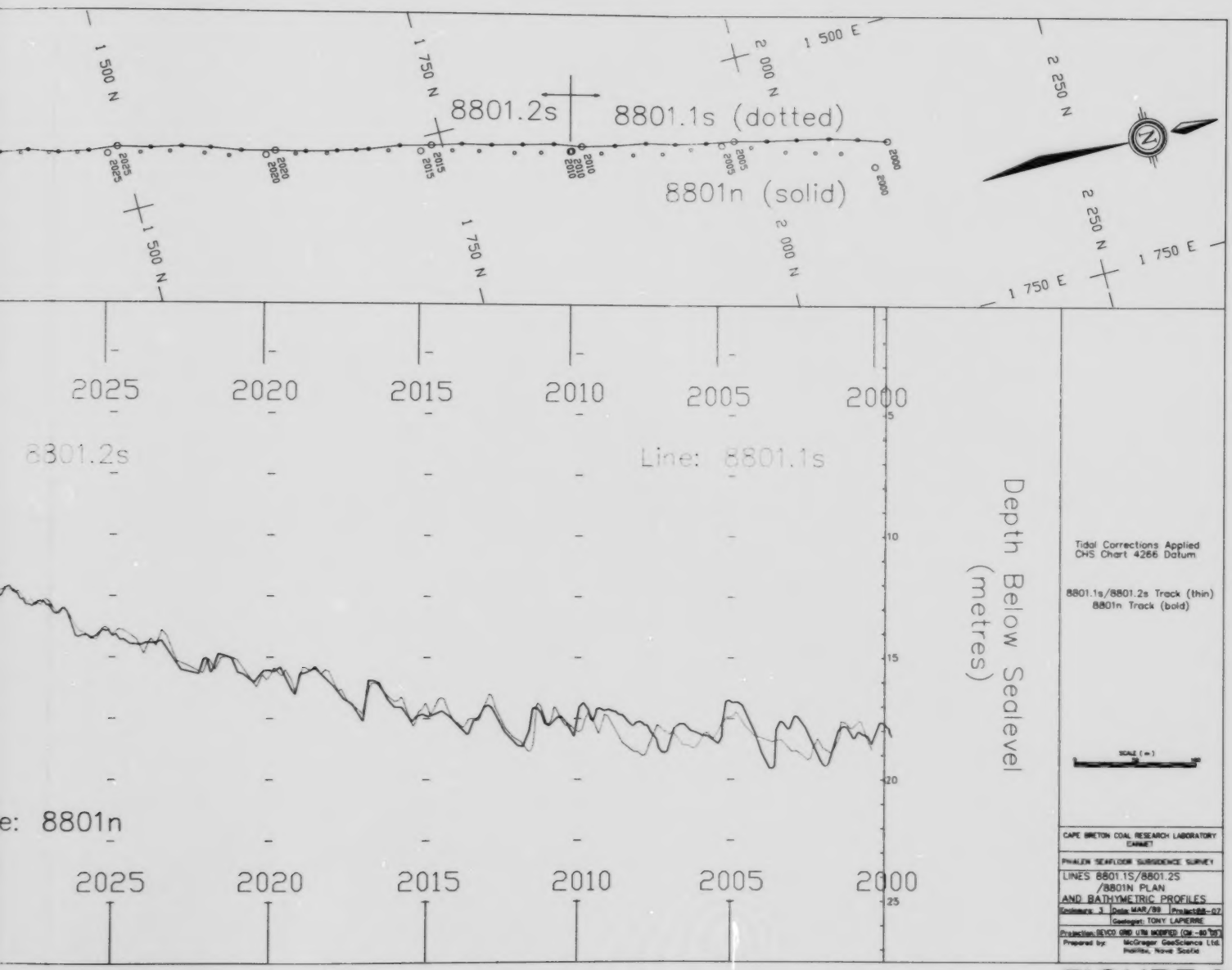
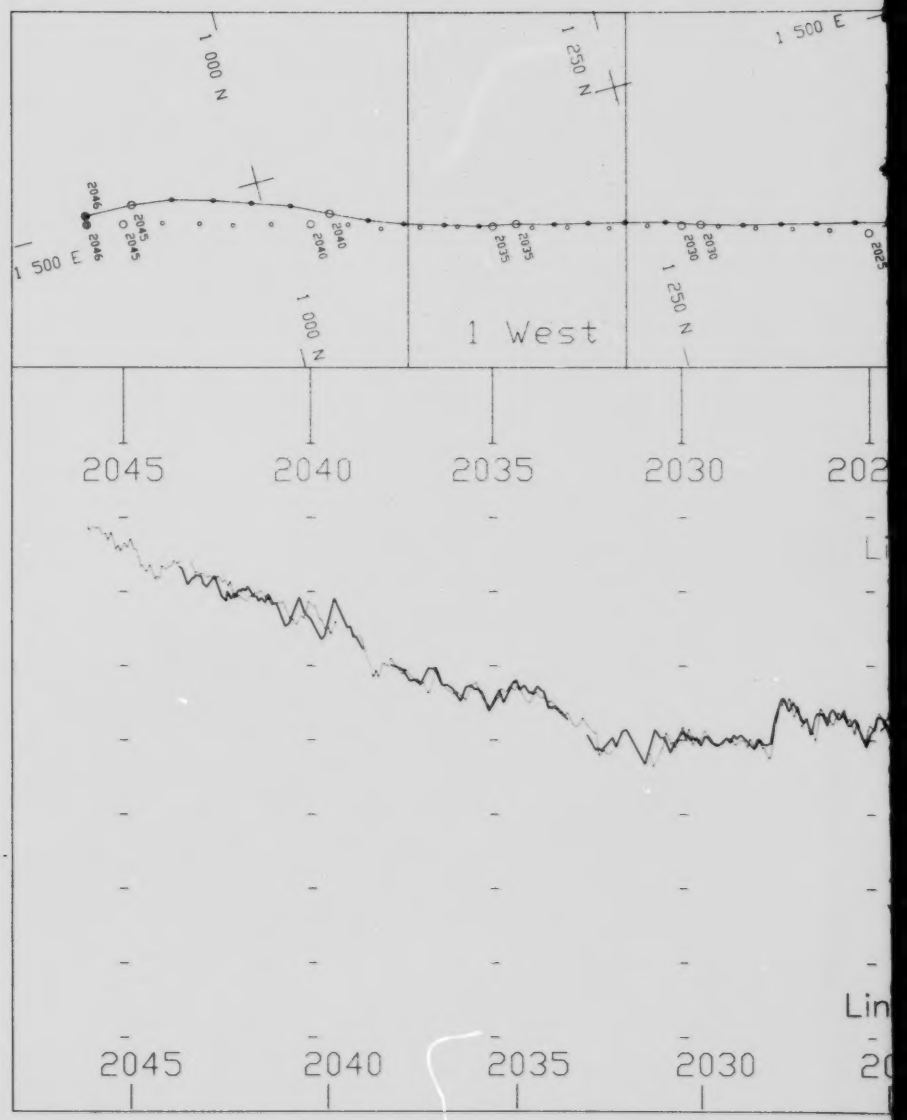

1 500 N
1 750 N
2 000 N
2 250 N
1 500 E
1 750 E
8801.2s
8801.1s (dotted)
8801n (solid)
2025
2020
2015
2010
2005
2000
Line: 8801.1s
8801.2s
e: 8801n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8801.1s/8801.2s Track (thin)
8801n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8801.1S/8801.2S
/8801N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: McGregor GeoScience Ltd.

FIGURE 3


1 000 N
1 250 N
1 500 E
1 West
2045
2040
2035
2030
Lin

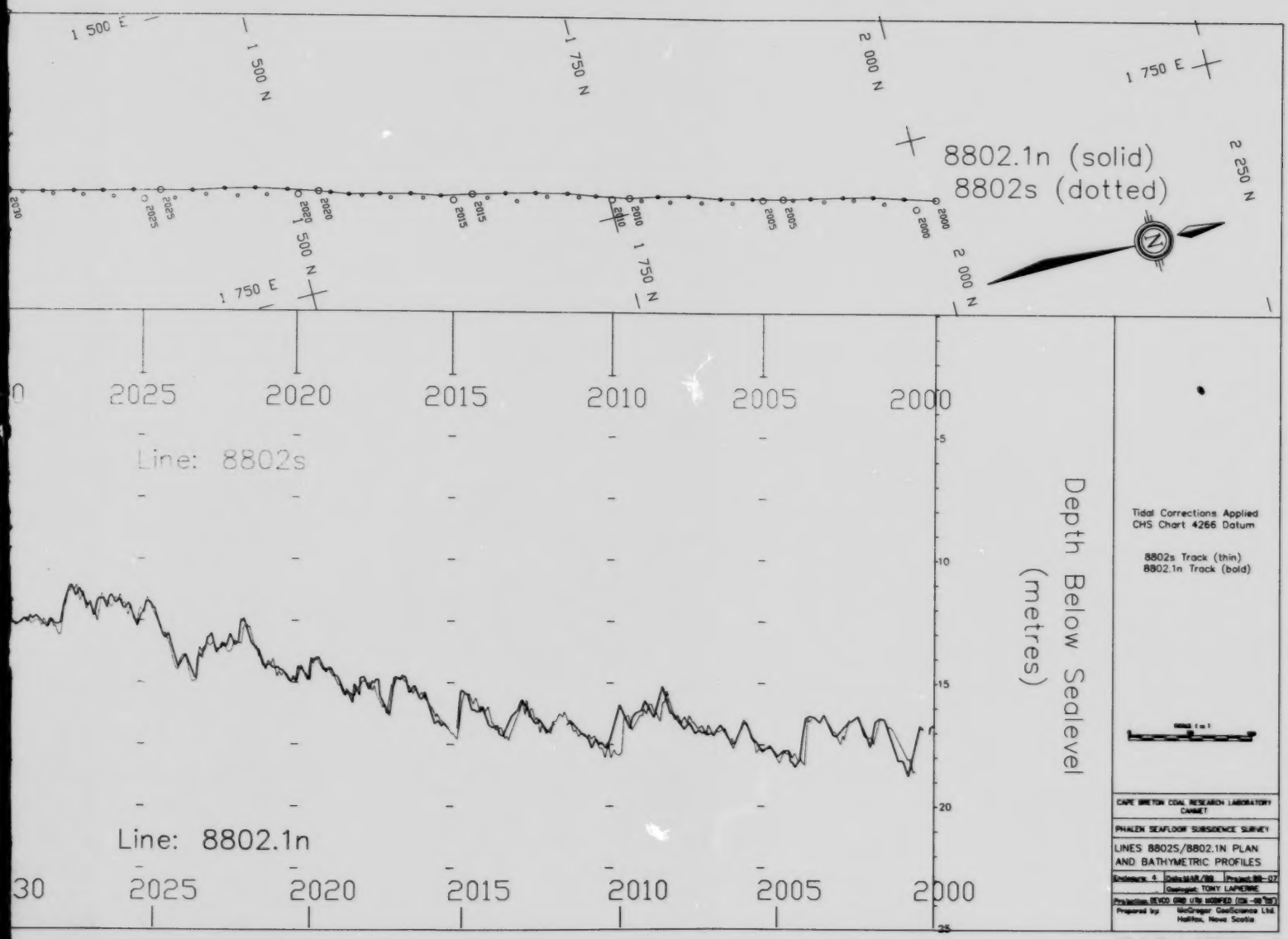
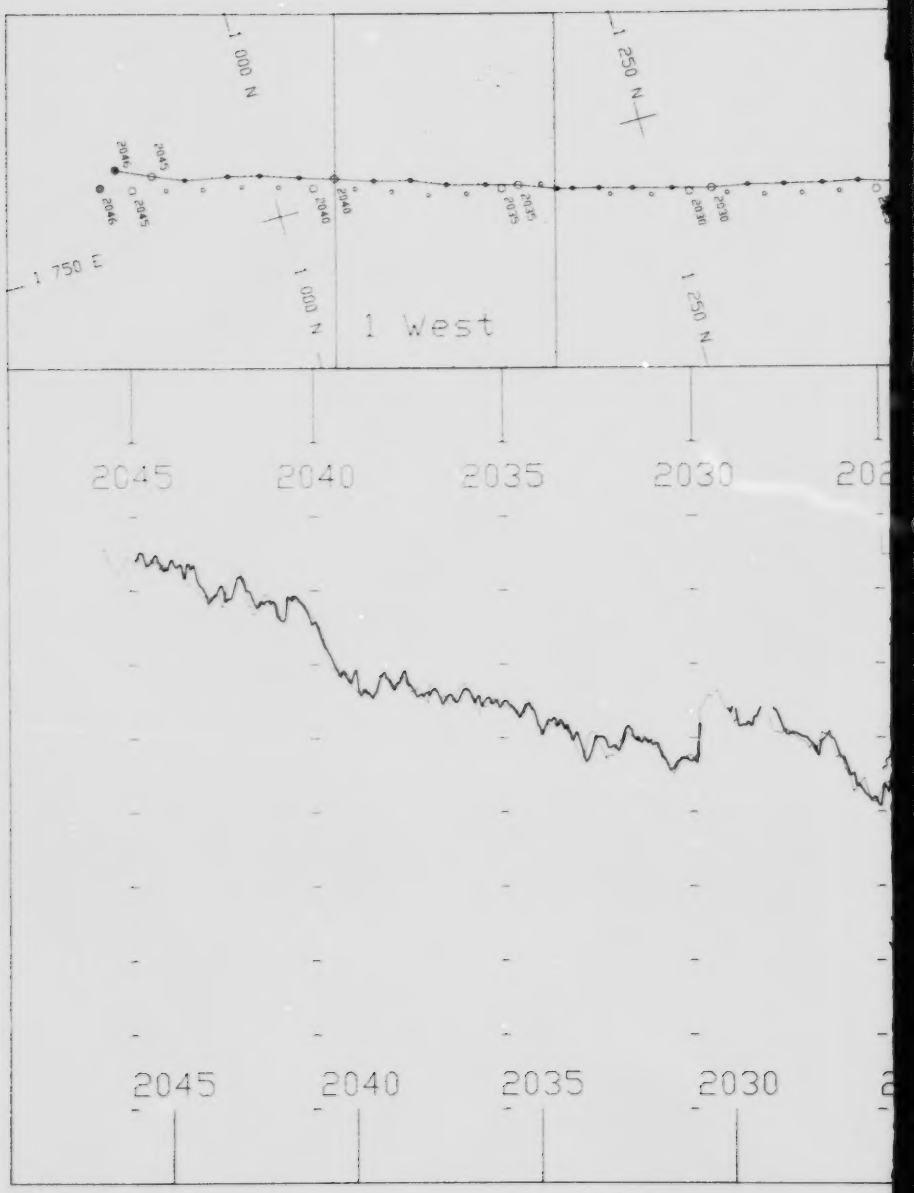

1 500 E
1 500 N
1 750 N
2 000 N
1 750 E
8802.1n (solid)
8802s (dotted)
2 250 N
2030
2025
2020
2015
2010
2005
2000
1 500 N
1 750 E
1 750 N
2 000 N
2025
2020
2015
2010
2005
2000
Line: 8802s
Line: 8802.1n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8802s Track (thin)
8802.1n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8802S/8802.1N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPHORNE
Prepared by: MacGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 4


1 000 N
1 250 N
1 750 E
1 000 N
1 250 N
1 West
2045
2040
2035
2030
2045
2040
2035
2030

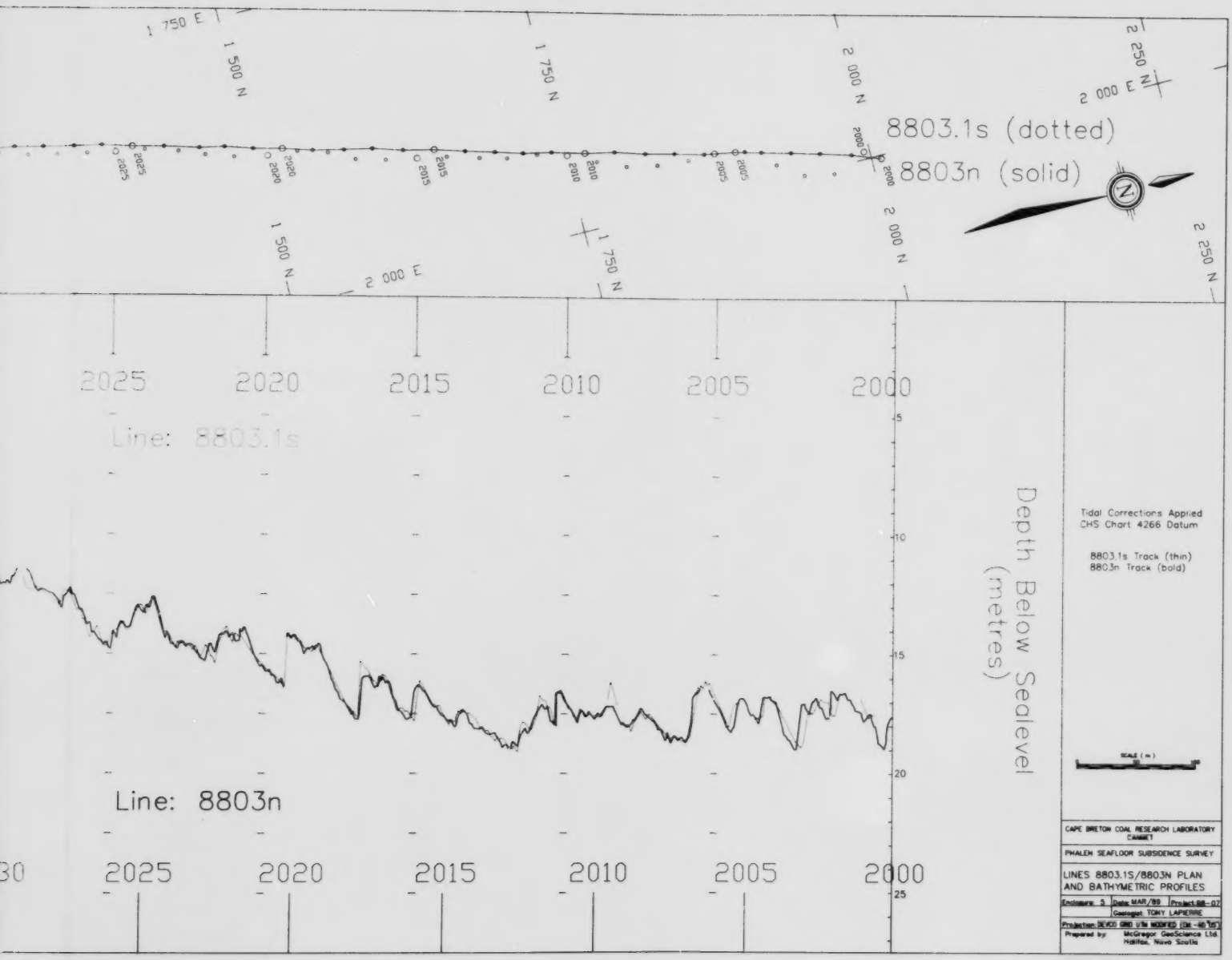
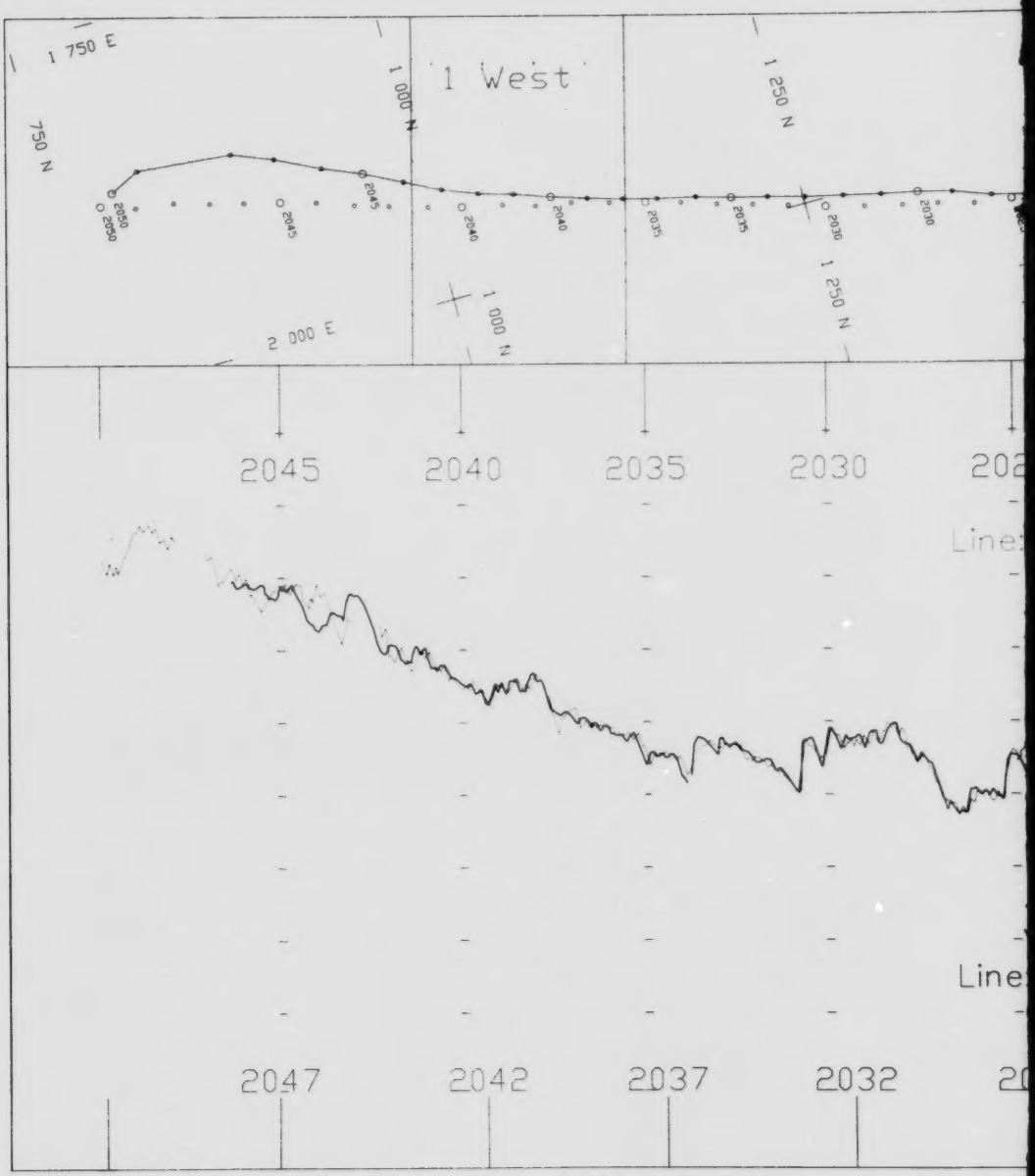

1 750 E
1 500 N
1 750 N
2 000 N
2 250 N
2 000 E
8803.1s (dotted)
8803n (solid)
2025
2020
2015
2010
2005
2000
Line: 8803.1s
Line: 8803n
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8803.1s Track (thin)
8803n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY LIMITED
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8803.1S/8803N PLAN AND BATHYMETRIC PROFILES
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 5


1 750 E
750 N
1 000 N
1 West
1 250 N
2 000 E
1 000 N
1 250 N
2050
2045
2040
2035
2030
2045
2040
2035
2030
Line
Line
2047
2042
2037
2032

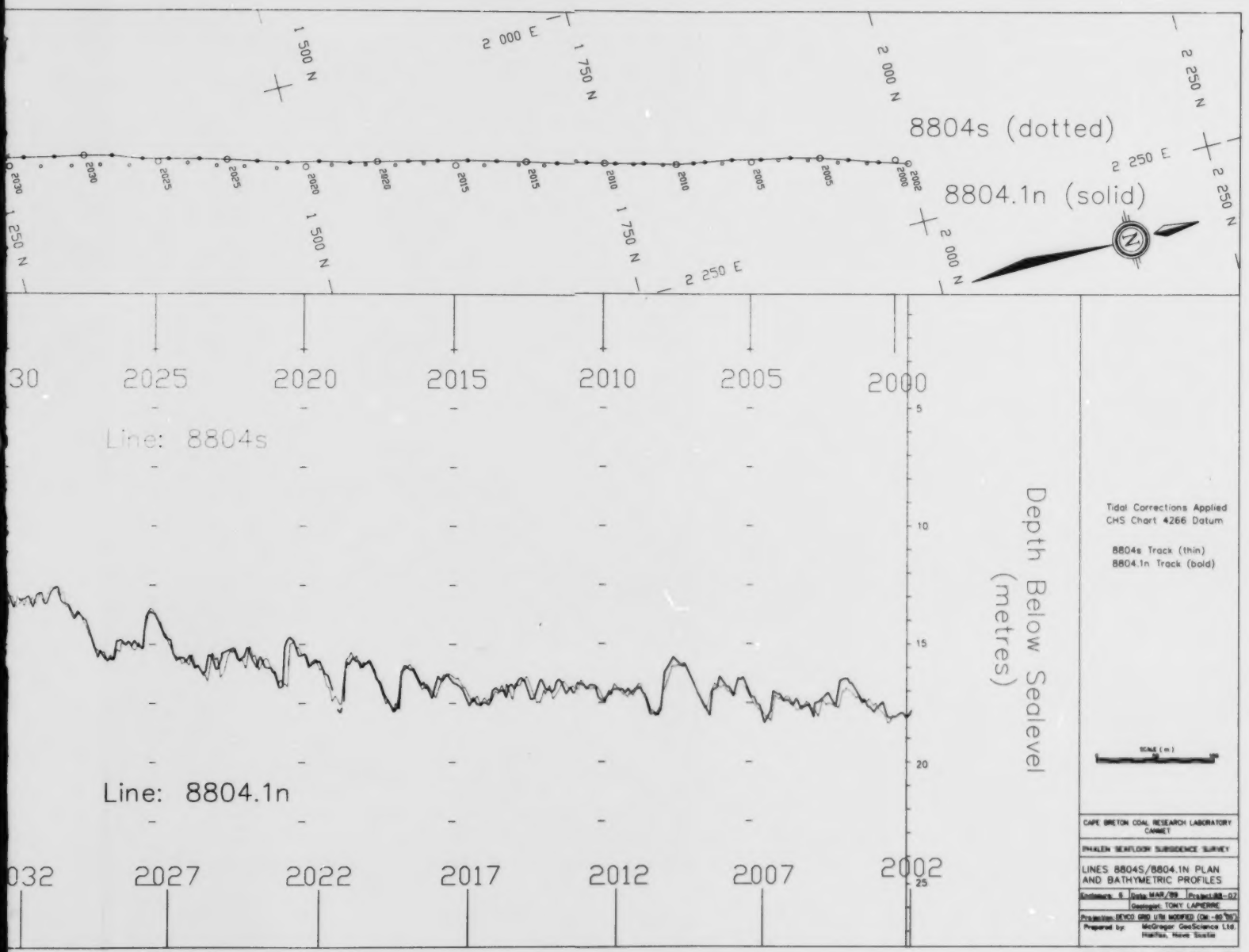
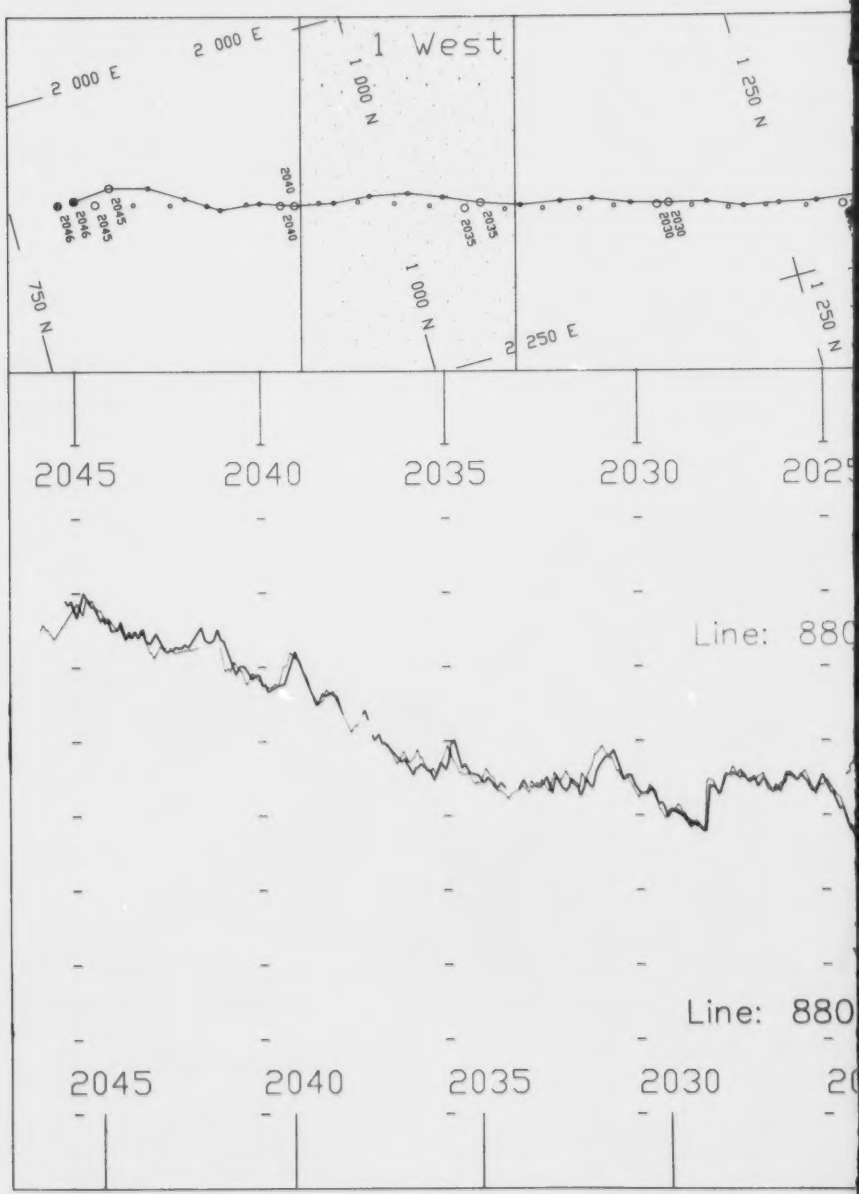

1 500 N
2 000 E
1 750 N
2 000 N
2 250 N
8804s (dotted)
2 250 E
8804.1n (solid)
2 250 N
2 000 N
1 250 N
1 500 N
1 750 N
2 250 E
2030
2025
2020
2015
2010
2005
2000
2002
Line: 8804s
Line: 8804.1n
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8804s Track (thin)
8804.1n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY CANMET
ENAKLEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8804S/8804.1N PLAN AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: McGregor GeoScience Ltd. Halifax, Nova Scotia

FIGURE 6


2 000 E
2 000 E
1 West
1 000 N
1 250 N
2040
2045
2046
2045
2046
2040
2035
2035
2030
2030
750 N
1 000 N
2 250 E
1 250 N
2045
2040
2035
2030
Line: 880
Line: 880
2045
2040
2035
2030

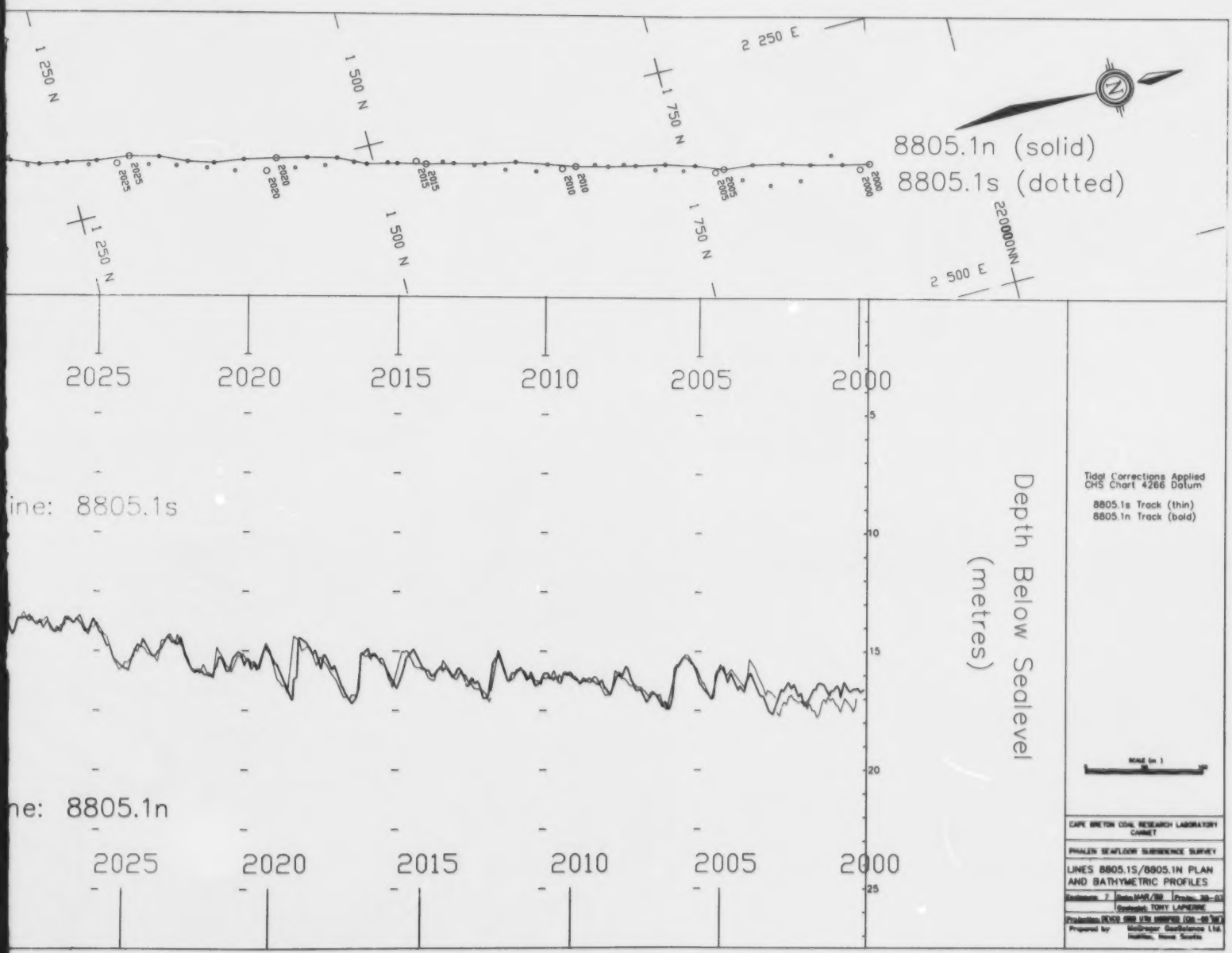
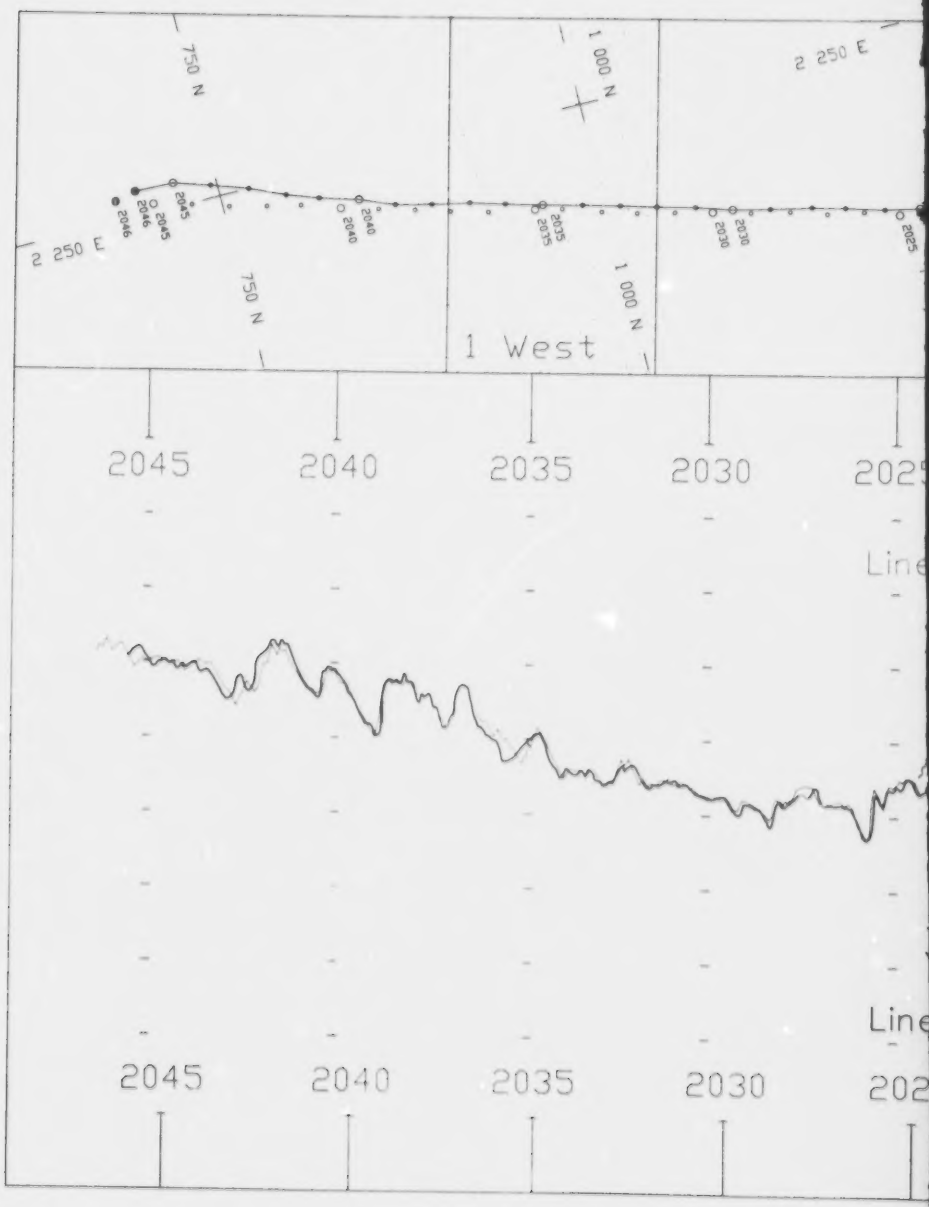

1 250 N
1 500 N
1 750 N
2 250 E
2 500 E
2220000NN
8805.1n (solid)
8805.1s (dotted)
2025
2020
2015
2010
2005
2000
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8805.1s Track (thin)
8805.1n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8805.1S/8805.1N PLAN
AND BATHYMETRIC PROFILES

FIGURE 7


750 N
1 000 N
2 250 E
2046
2045
2040
2035
2030
2025
1 West
2045
2040
2035
2030
Line
Line
2045
2040
2035
2030

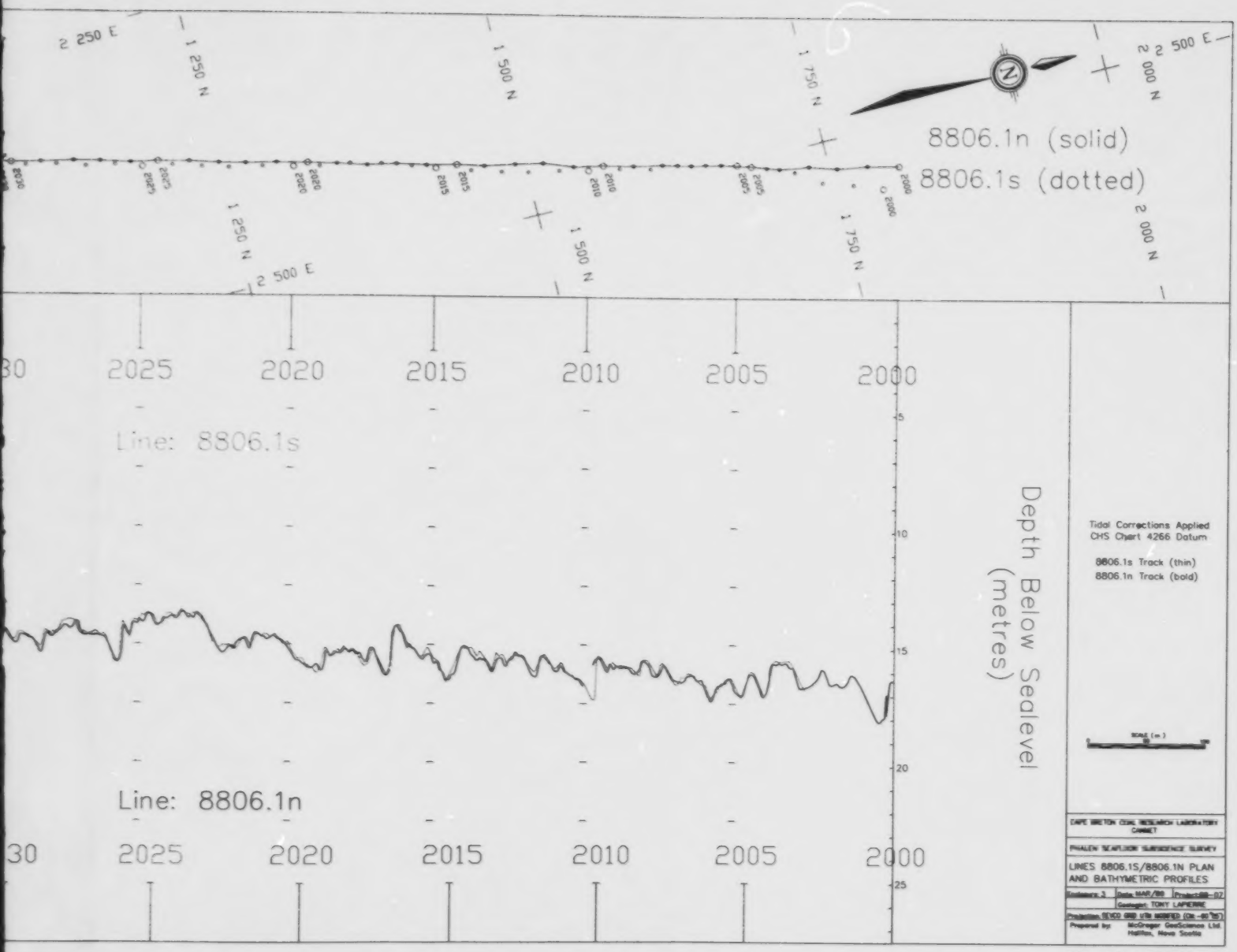
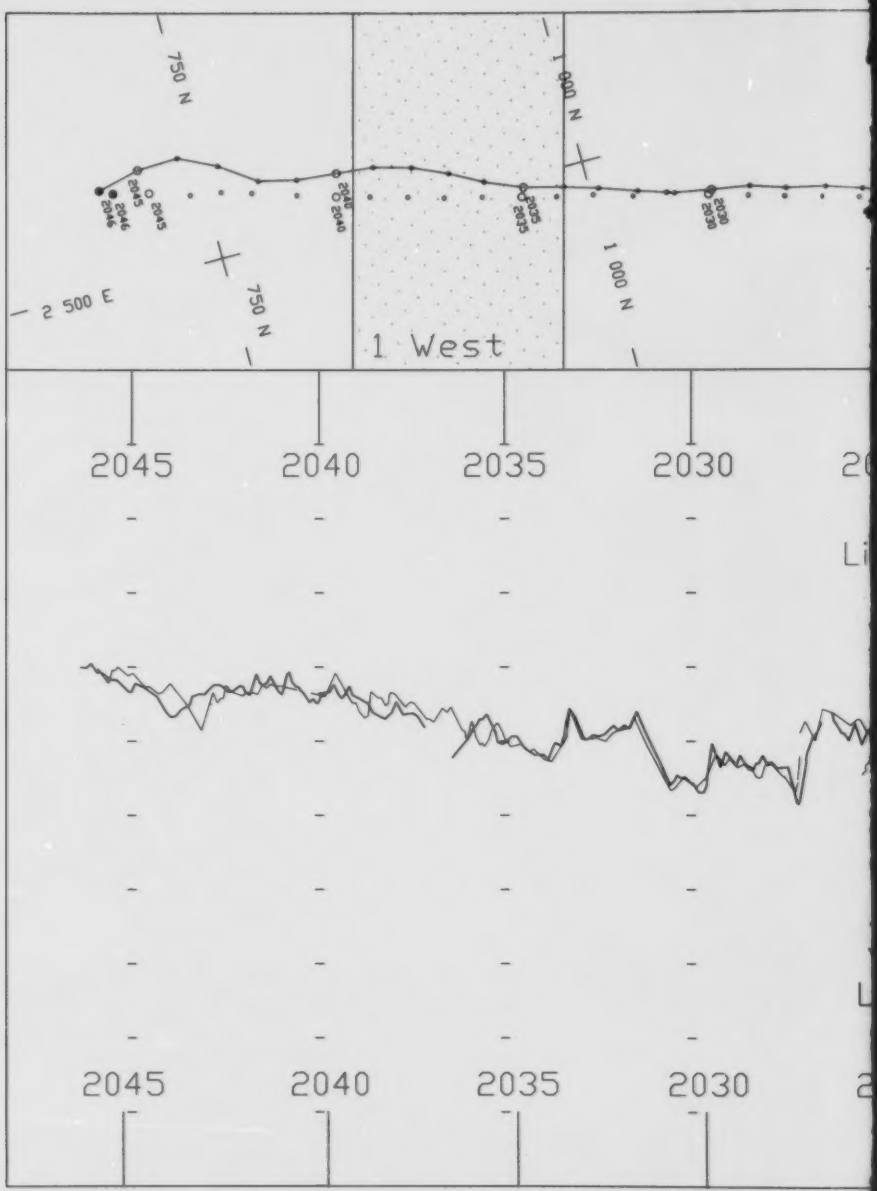

2 250 E
1 250 N
1 500 N
1 750 N
2 500 E
2 000 N
8806.1n (solid)
8806.1s (dotted)
2030
2025
2020
2015
2010
2005
2000
Line: 8806.1s
Line: 8806.1n
Depth Below Sealevel (metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8806.1s Track (thin)
8806.1n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY LIMITED
PHALEN SEAPLUME SUBSIDENCE SURVEY
LINES 8806.1S/8806.1N PLAN AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 8


750 N
1 000 N
2 500 E
750 N
1 000 N
1 West
2045
2040
2035
2030
2045
2040
2035
2030

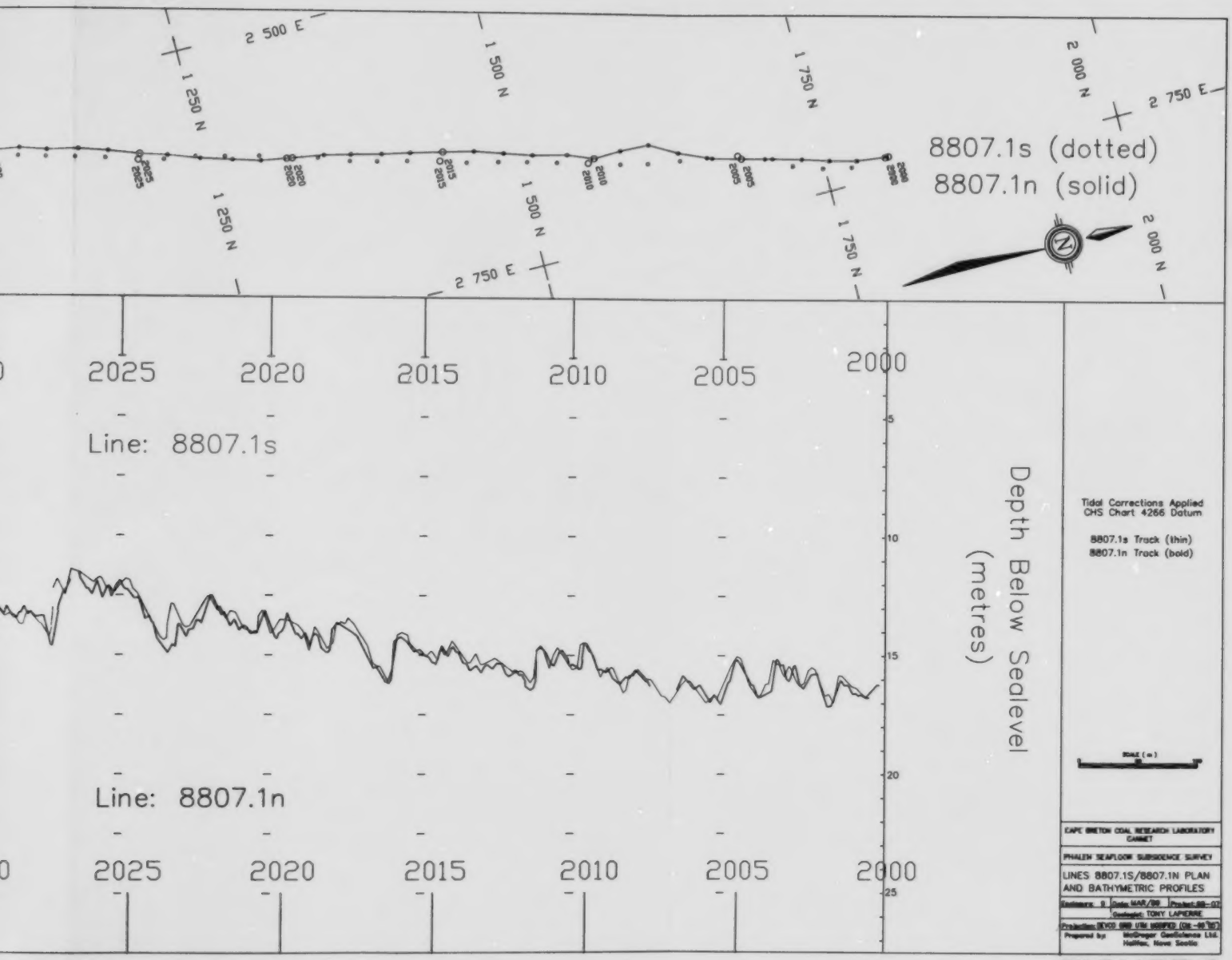
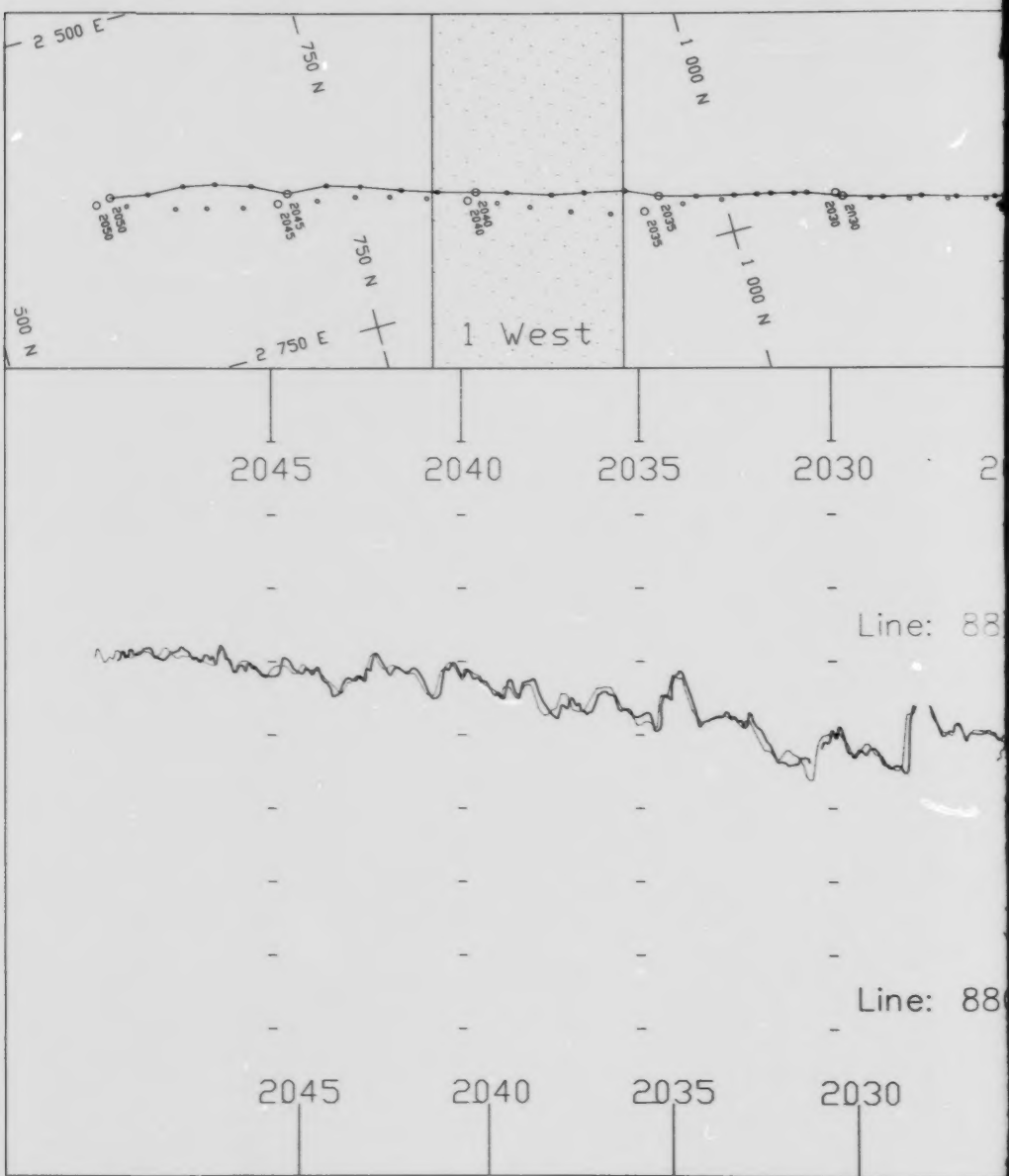

2 500 E
1 250 N
1 500 N
1 750 N
2 000 N
2 750 E
8807.1s (dotted)
8807.1n (solid)
N
2025
2020
2015
2010
2005
2000
Line: 8807.1s
Line: 8807.1n
Depth Below Sealevel
(metres)
5
10
15
20
25
Tidal Corrections Applied
CHS Chart 4266 Datum
8807.1s Track (thin)
8807.1n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8807.1S/8807.1N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 9


2 500 E
750 N
1 000 N
2050
2045
2040
2035
2030
750 N
1 000 N
500 N
2 750 E
1 West
2045
2040
2035
2030
Line: 88
Line: 88
2045
2040
2035
2030

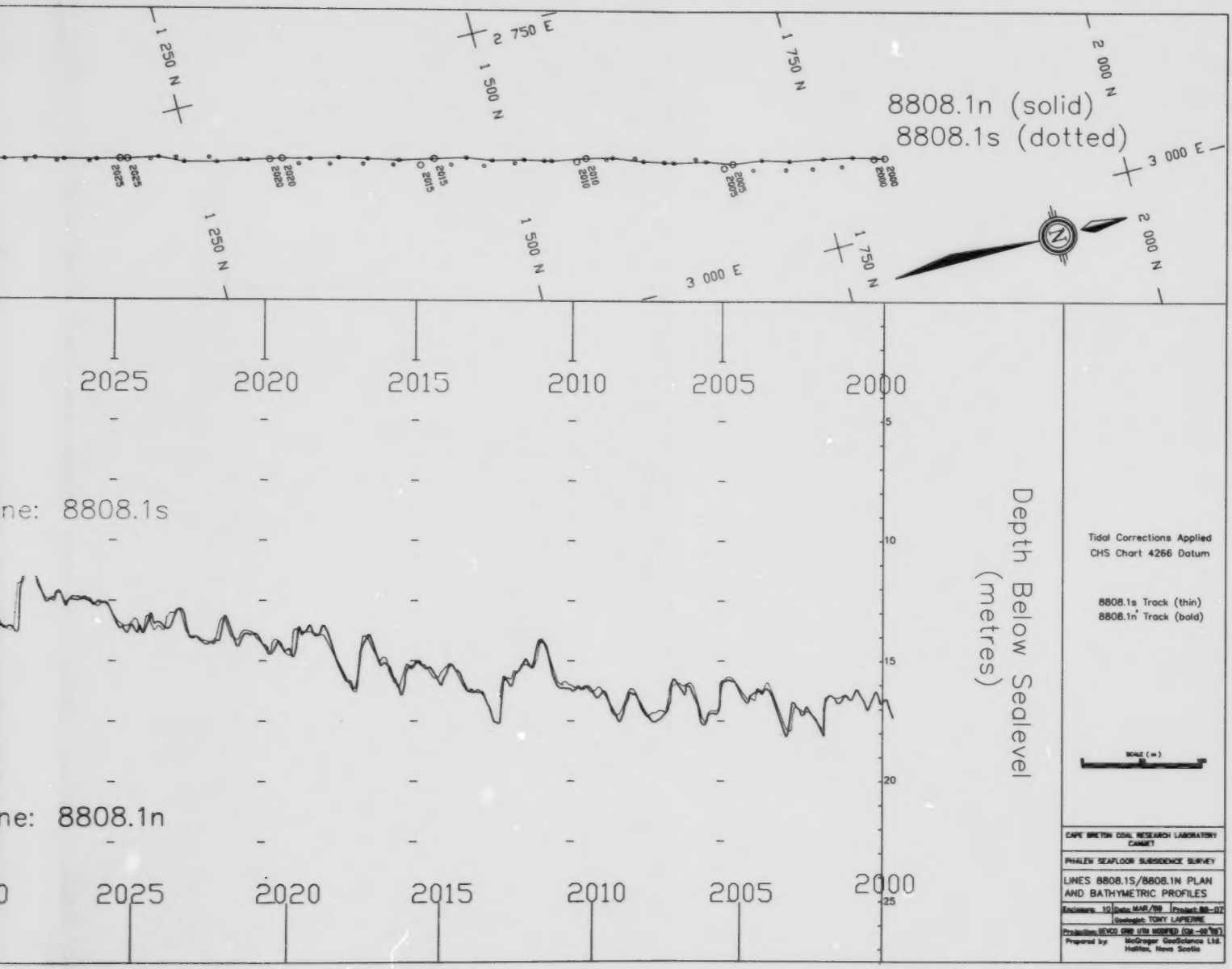
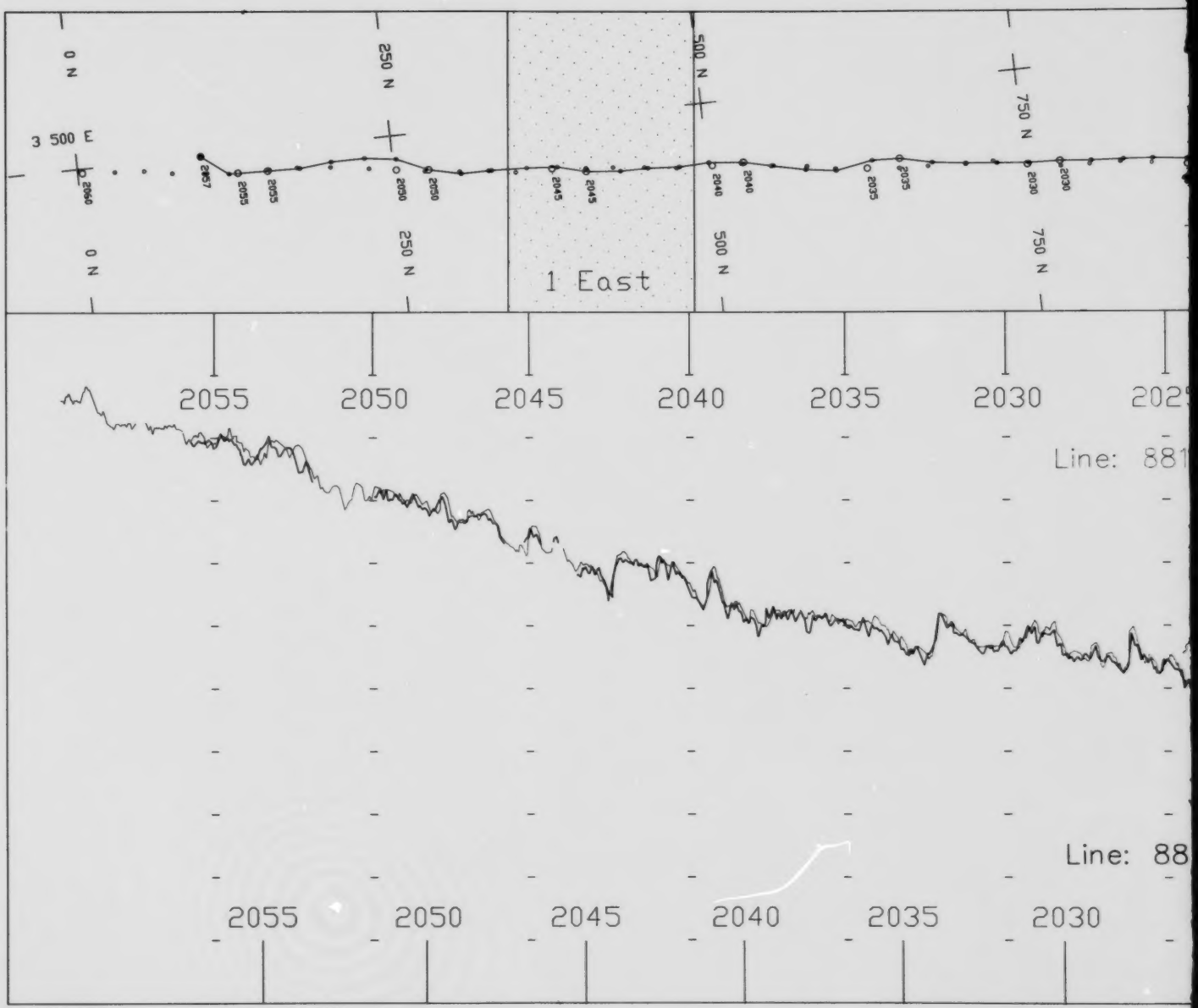

1 250 N
2 750 E
1 500 N
1 750 N
2 000 N
8808.1n (solid)
8808.1s (dotted)
3 000 E
2025
2020
2015
2010
2005
2000
ne: 8808.1s
ne: 8808.1n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8808.1s Track (thin)
8808.1n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8808.1S/8808.1N PLAN
AND BATHYMETRIC PROFILES
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 10


0 N
250 N
500 N
750 N
3 500 E
1 East
2055
2050
2045
2040
2035
2030
Line: 881
Line: 88

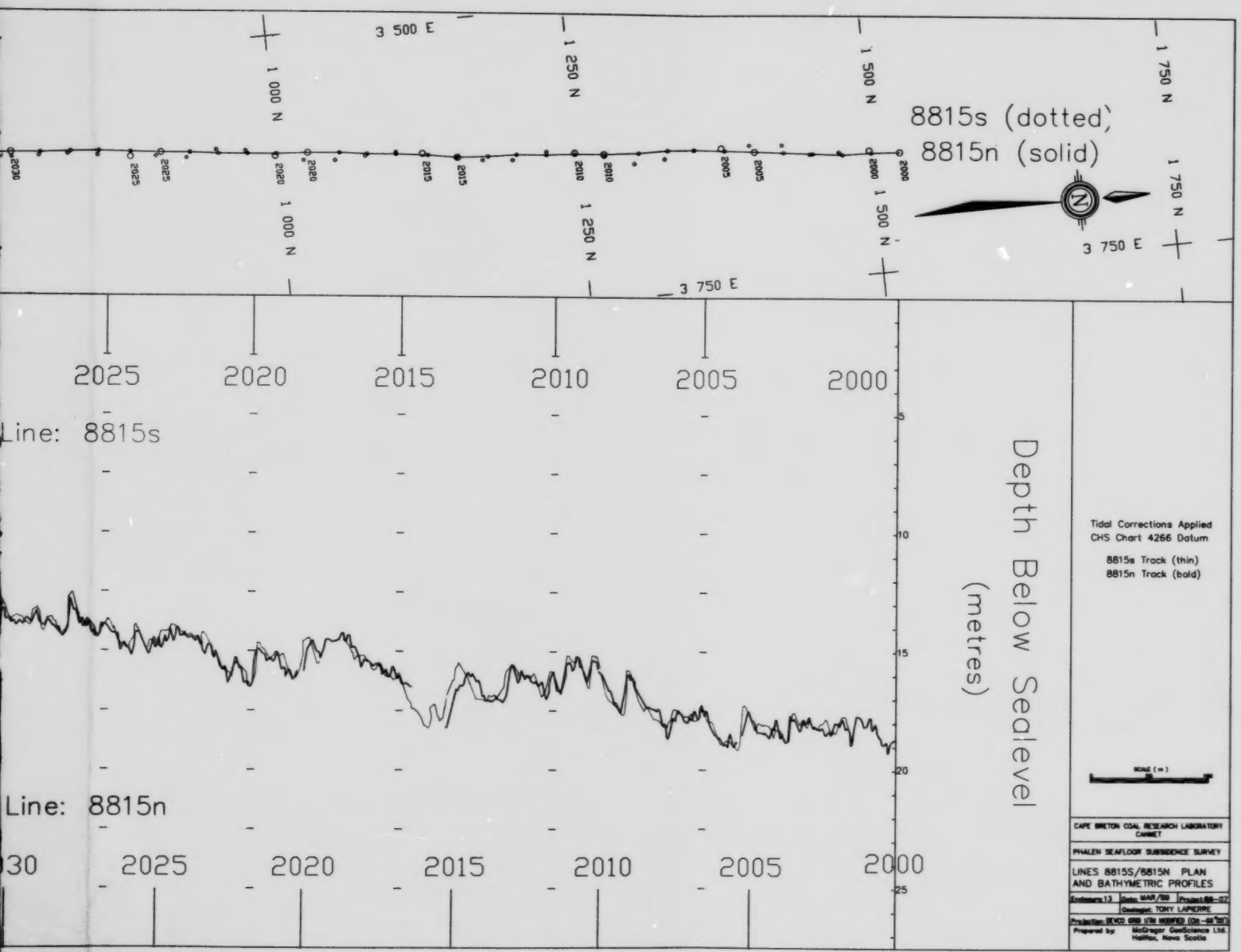
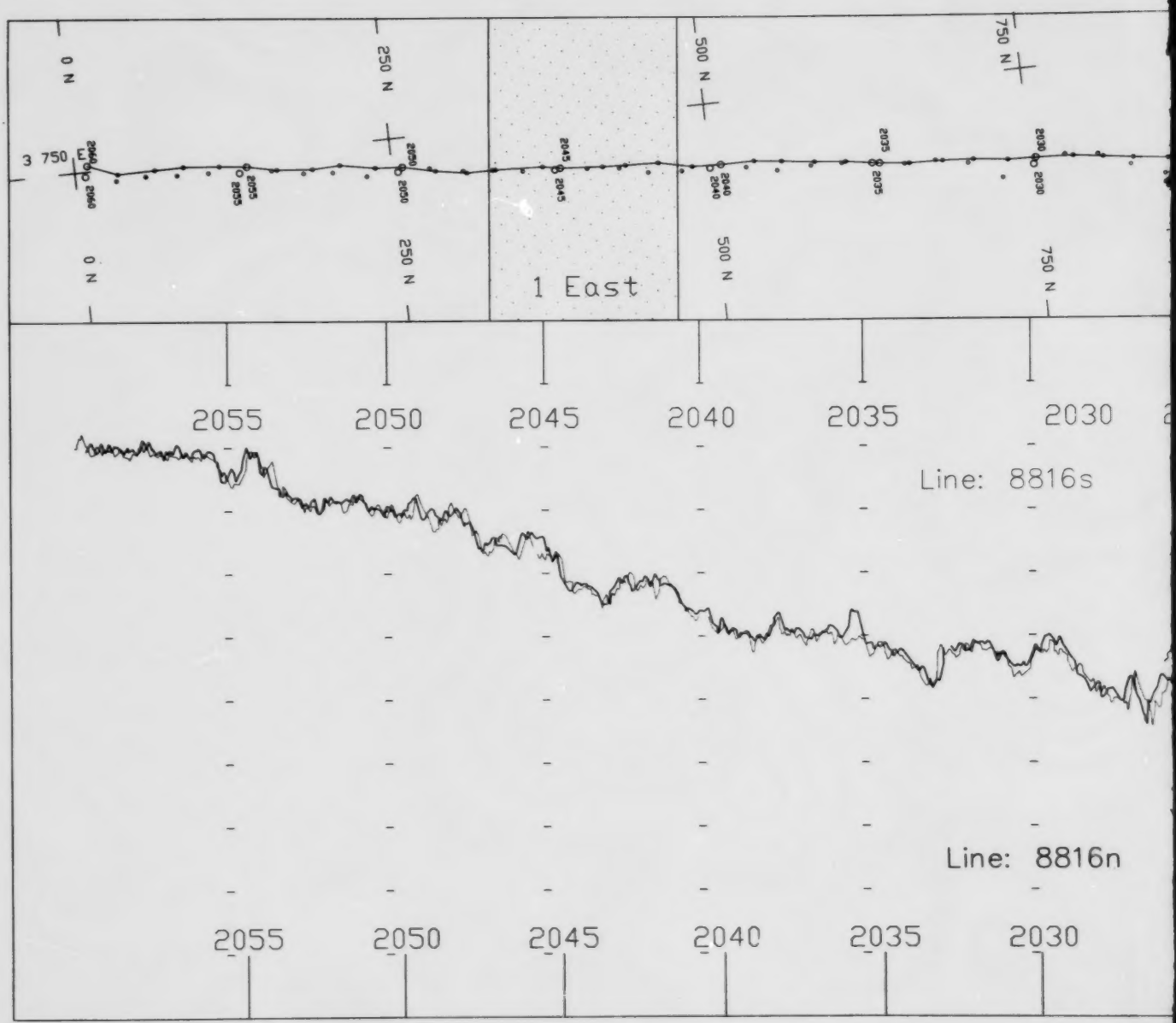

3 500 E
1 000 N
1 250 N
1 500 N
1 750 N
8815s (dotted)
8815n (solid)
3 750 E
2030
2025
2020
2015
2010
2005
2000
Line: 8815s
Line: 8815n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8815s Track (thin)
8815n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8815S/8815N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: MacGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 11


0 N
250 N
500 N
750 N
3 750 E
1 East
2055
2050
2045
2040
2035
2030
Line: 8816s
Line: 8816n

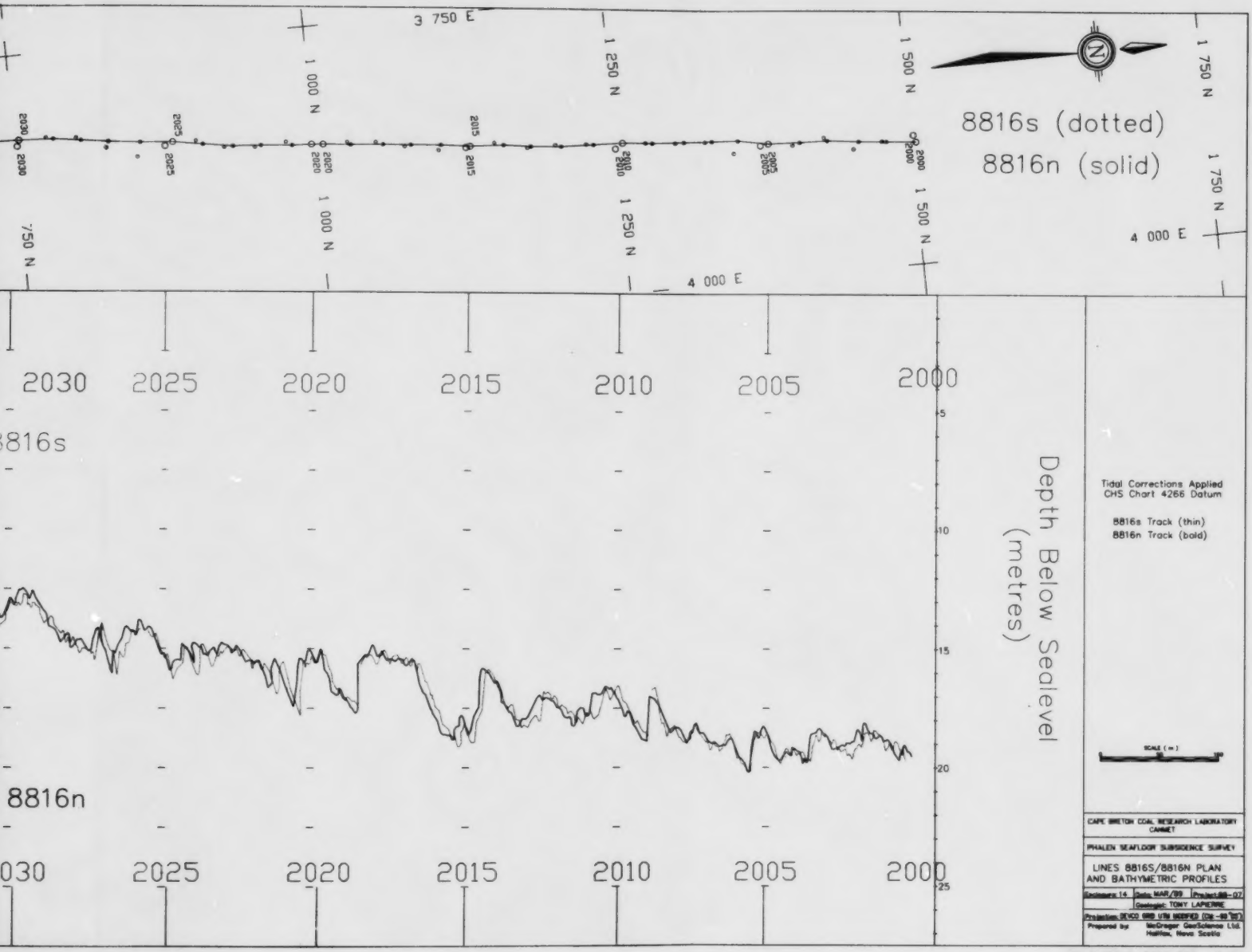
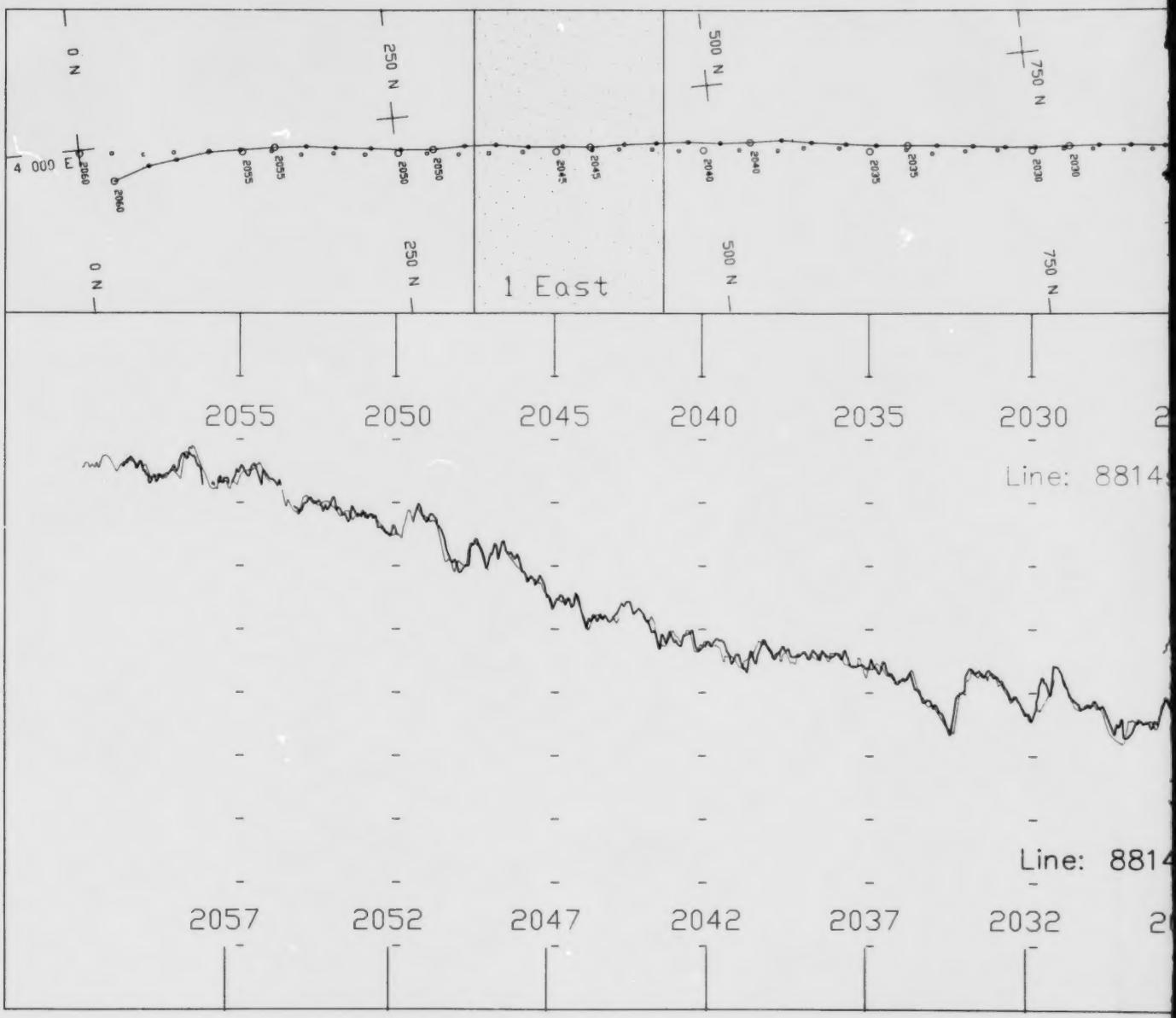

3 750 E
1 000 N
1 250 N
1 500 N
1 750 N
4 000 E
8816s (dotted)
8816n (solid)
2030
2025
2020
2015
2010
2005
2000
8816s
8816n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8816s Track (thin)
8816n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8816S/8816N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: MacDrager GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 12


0 N
250 N
500 N
750 N
4 000 E
2060
2055
2050
2045
2040
2035
2030
1 East
2055
2050
2045
2040
2035
2030
Line: 8814
Line: 8814
2057
2052
2047
2042
2037
2032

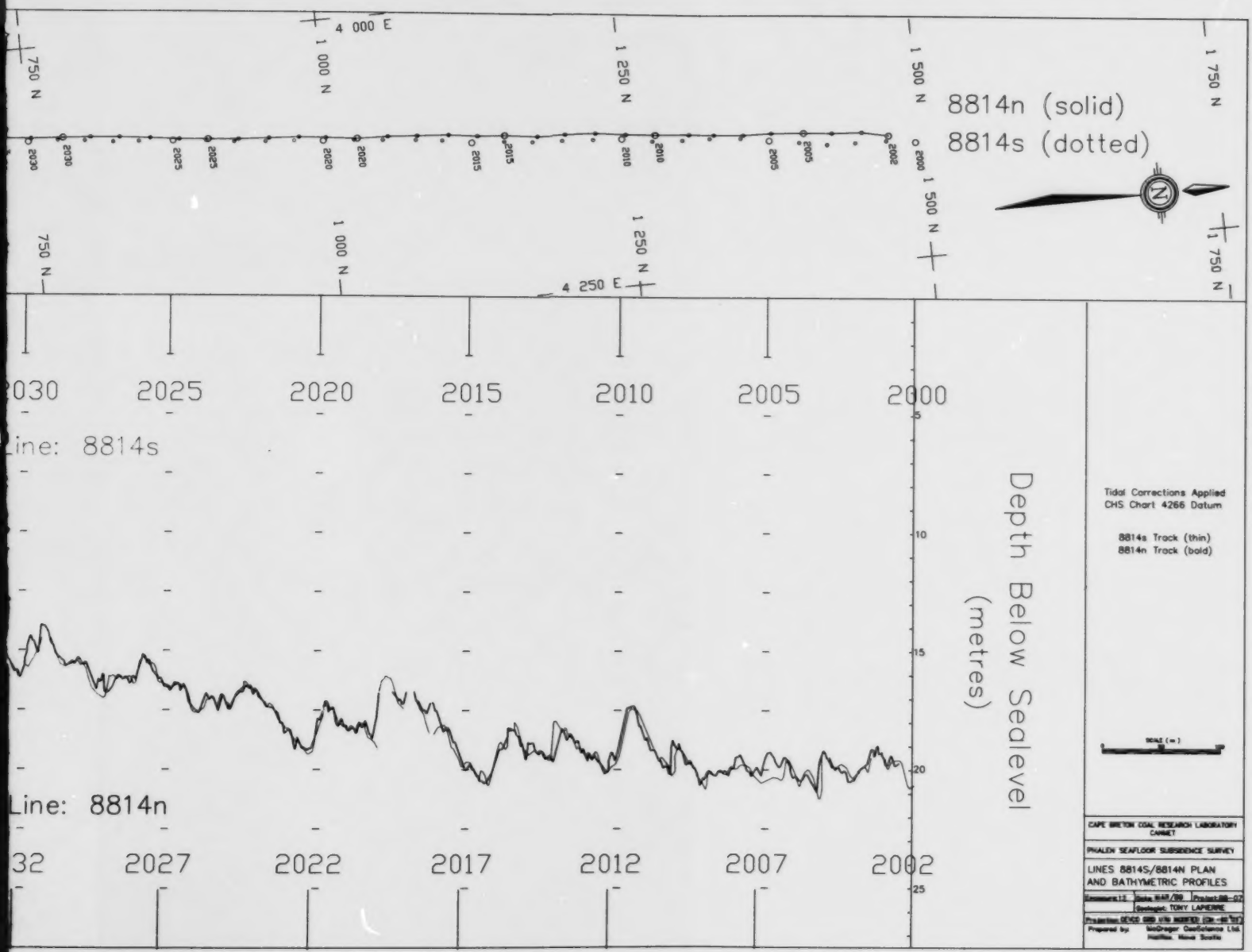
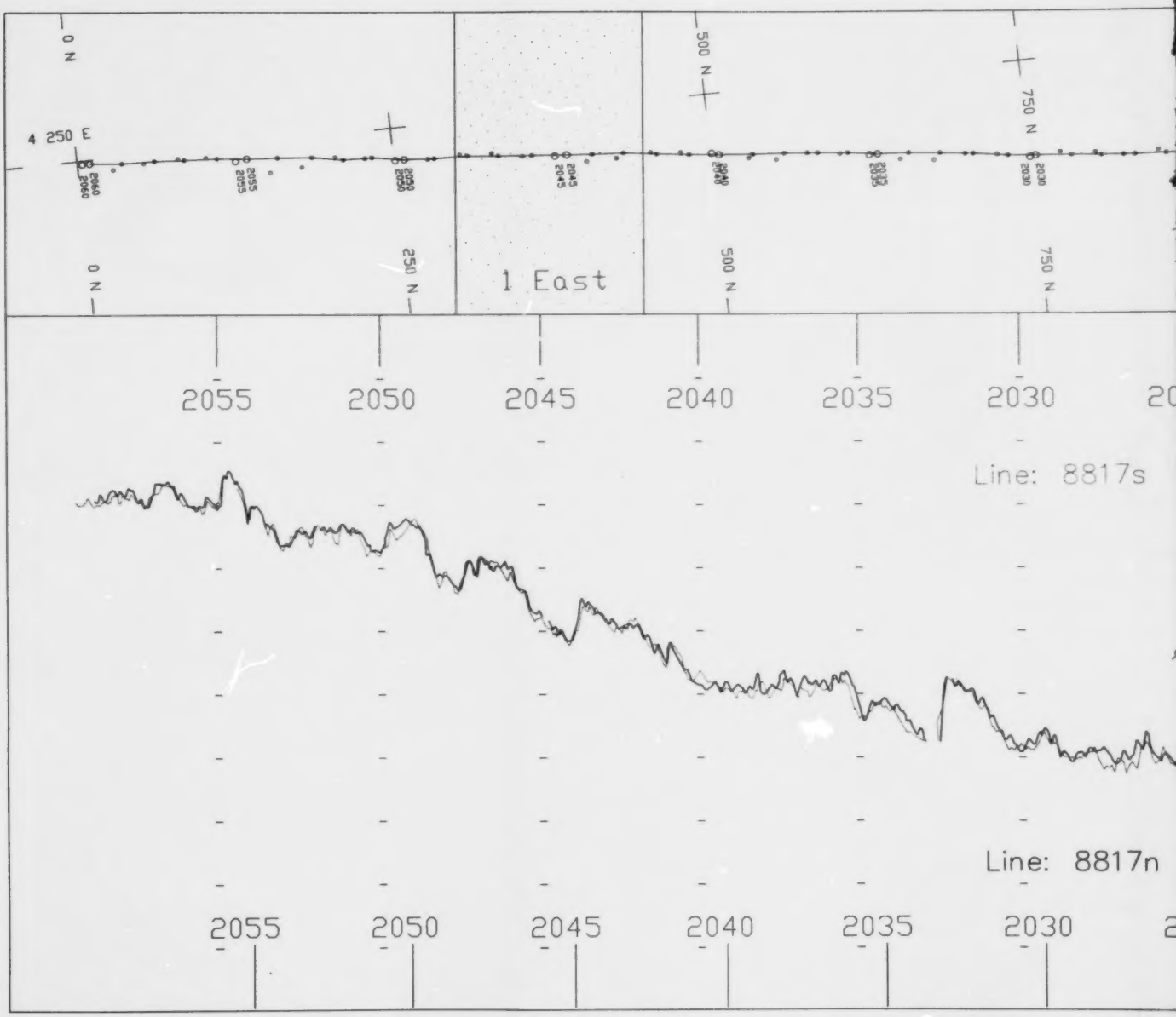

4 000 E
4 250 E
750 N
1 000 N
1 250 N
1 500 N
1 750 N
8814n (solid)
8814s (dotted)
2030
2025
2020
2015
2010
2005
2000
Line: 8814s
Line: 8814n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8814s Track (thin)
8814n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8814S/8814N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE

FIGURE 13


0 N
4 250 E
2060
2055
2050
250 N
1 East
2045
500 N
2040
2035
750 N
2030
2055
2050
2045
2040
2035
2030
Line: 8817s
Line: 8817n
2055
2050
2045
2040
2035
2030

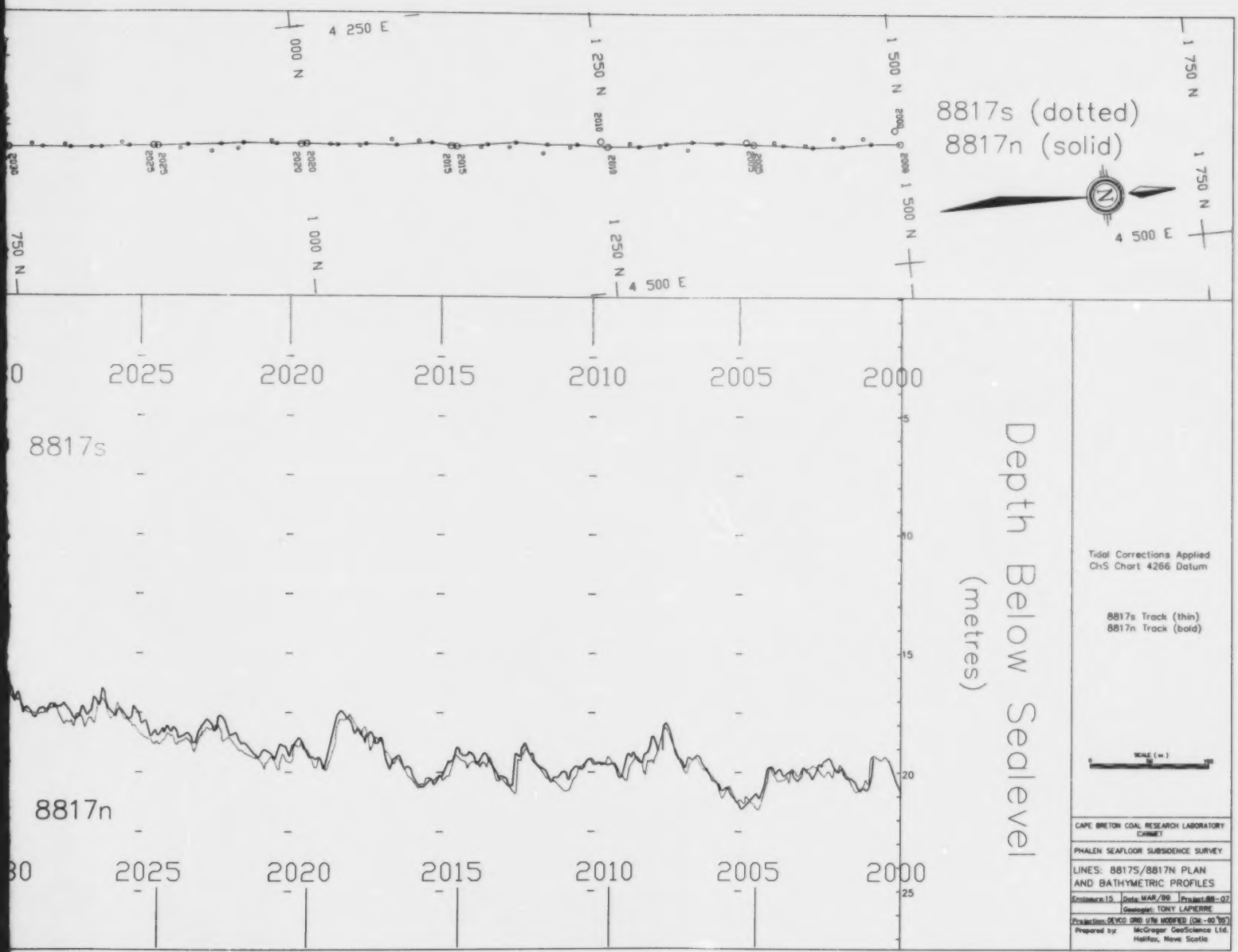
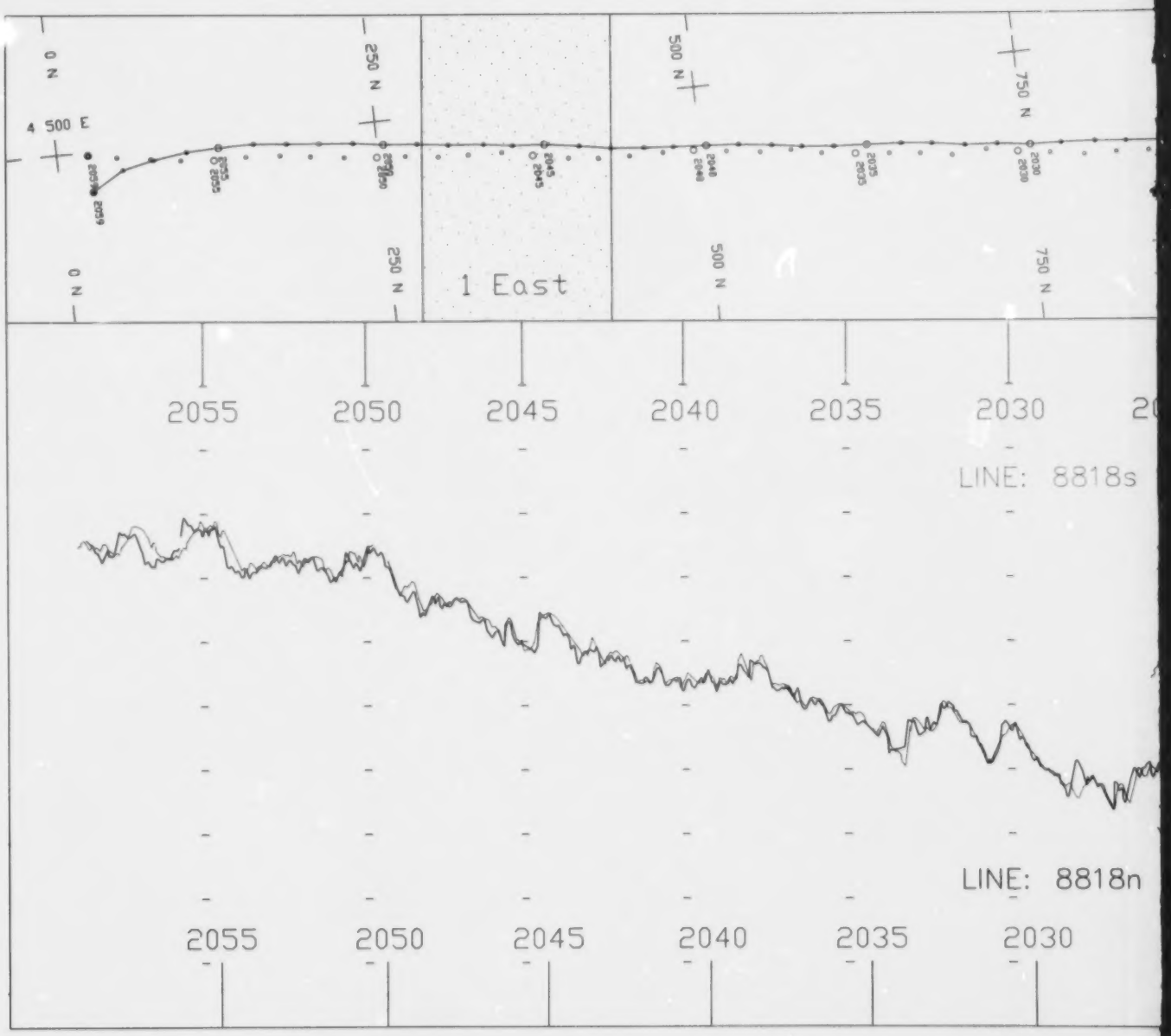

4 250 E
1 000 N
1 250 N
1 500 N
1 750 N
8817s (dotted)
8817n (solid)
4 500 E
750 N
1 000 N
1 250 N
4 500 E
2025
2020
2015
2010
2005
2000
8817s
8817n
Depth Below Sealevel
(metres)
5
10
15
20
25
Tidal Corrections Applied
ChS Chart 4266 Datum
8817s Track (thin)
8817n Track (bold)
SCALE (m)
CAPE BRETON COAL RESEARCH LABORATORY
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES: 8817S/8817N PLAN
AND BATHYMETRIC PROFILES
Enclosure 15
Date: MAR/99
Project:88-07
Geologist: TONY LAPIERRE
Projection: DEVCO GRID UTM MODIFIED (CM:-60°00')
Prepared by:
McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 14


0 N
250 N
500 N
750 N
4 500 E
1 East
2055
2050
2045
2040
2035
2030
LINE: 8818s
LINE: 8818n

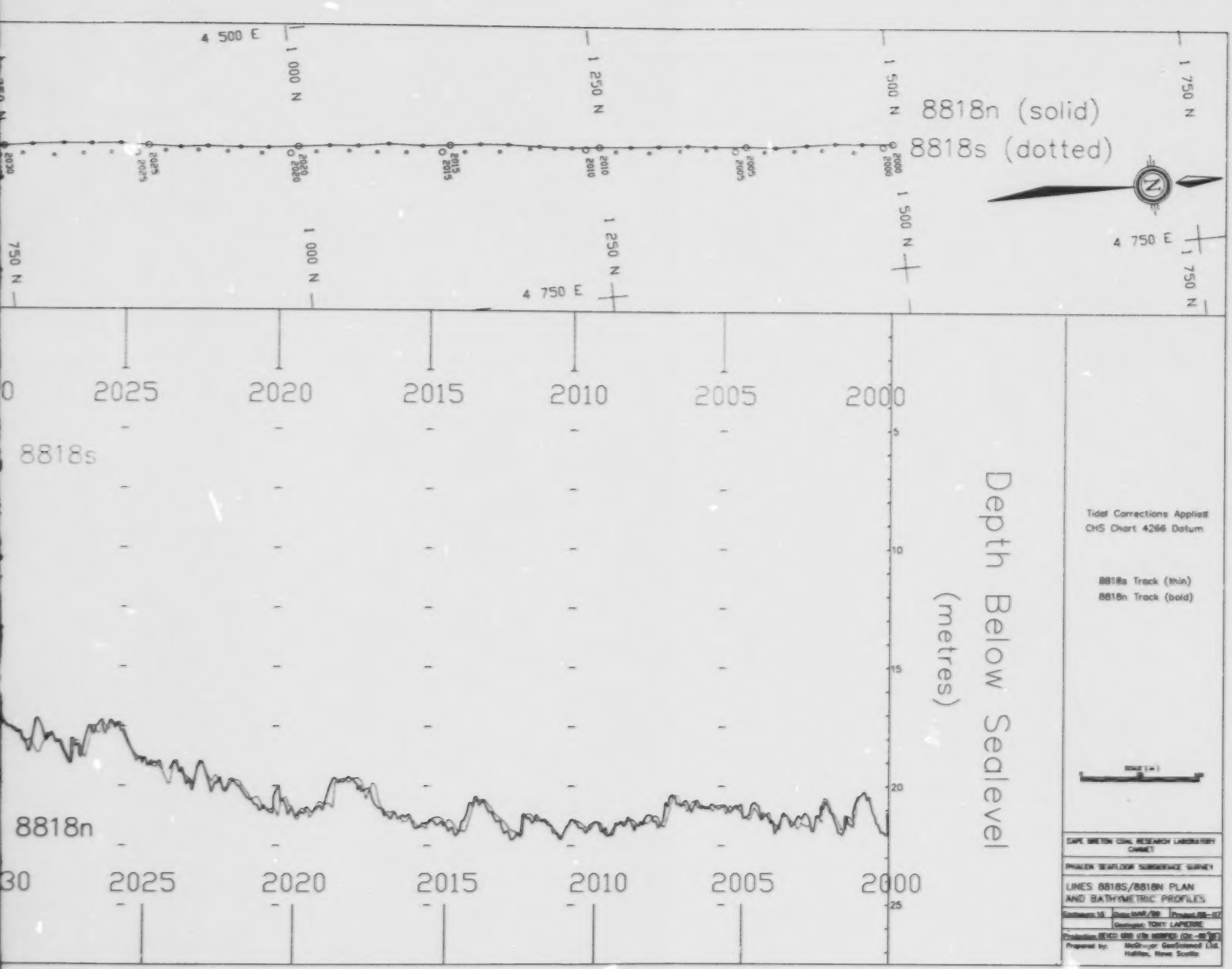
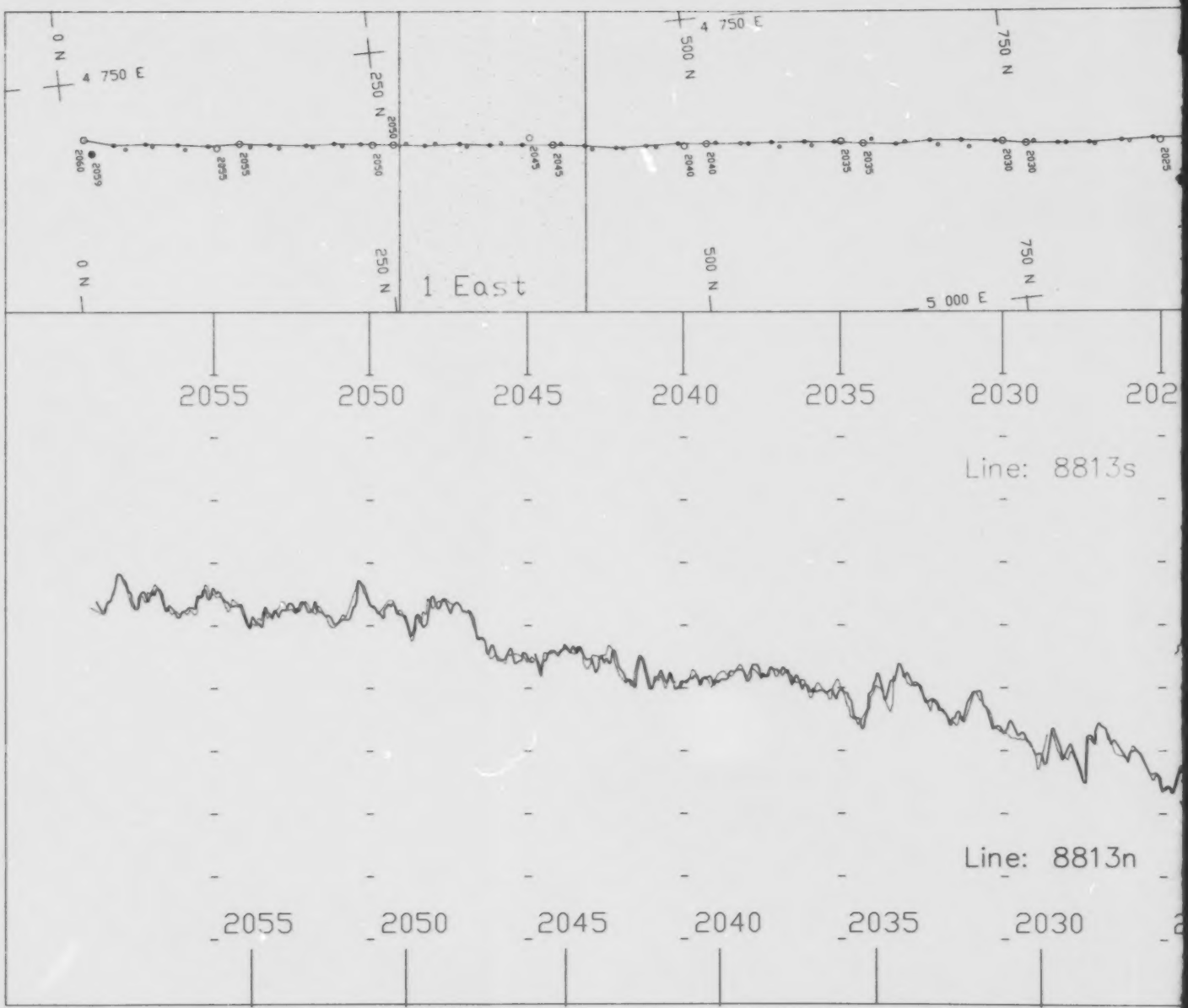

4 500 E
1 000 N
1 250 N
1 500 N
1 750 N
8818n (solid)
8818s (dotted)
4 750 E
2025
2020
2015
2010
2005
2000
8818s
8818n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8818s Track (thin)
8818n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8818S/8818N PLAN
AND BATHYMETRIC PROFILES
Prepared by:
McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 15


0 N
4 750 E
250 N
2060
2059
2055
2050
2045
4 750 E
500 N
750 N
2040
2035
2030
1 East
5 000 E
2055
2050
2045
2040
2035
2030
Line: 8813s
Line: 8813n

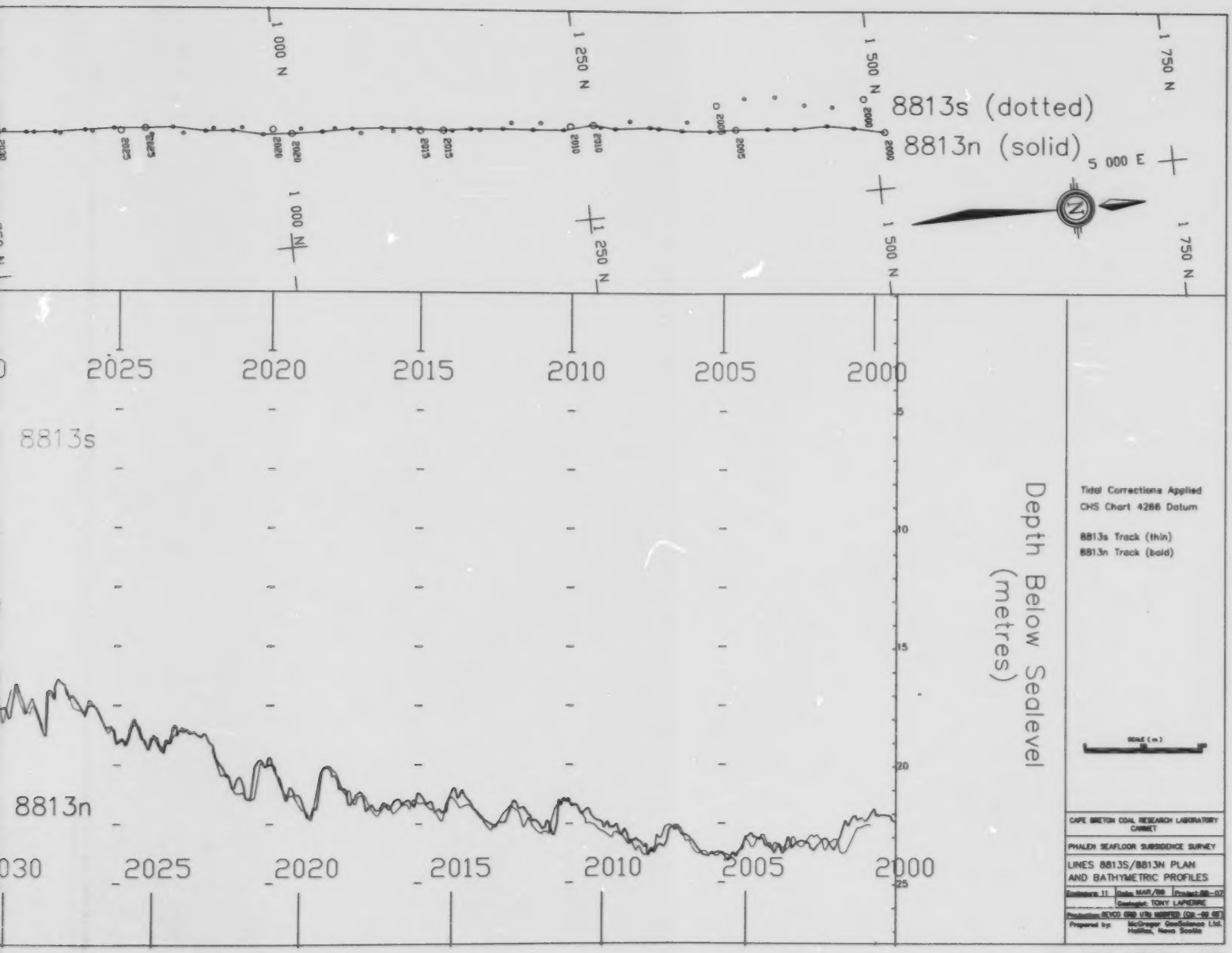
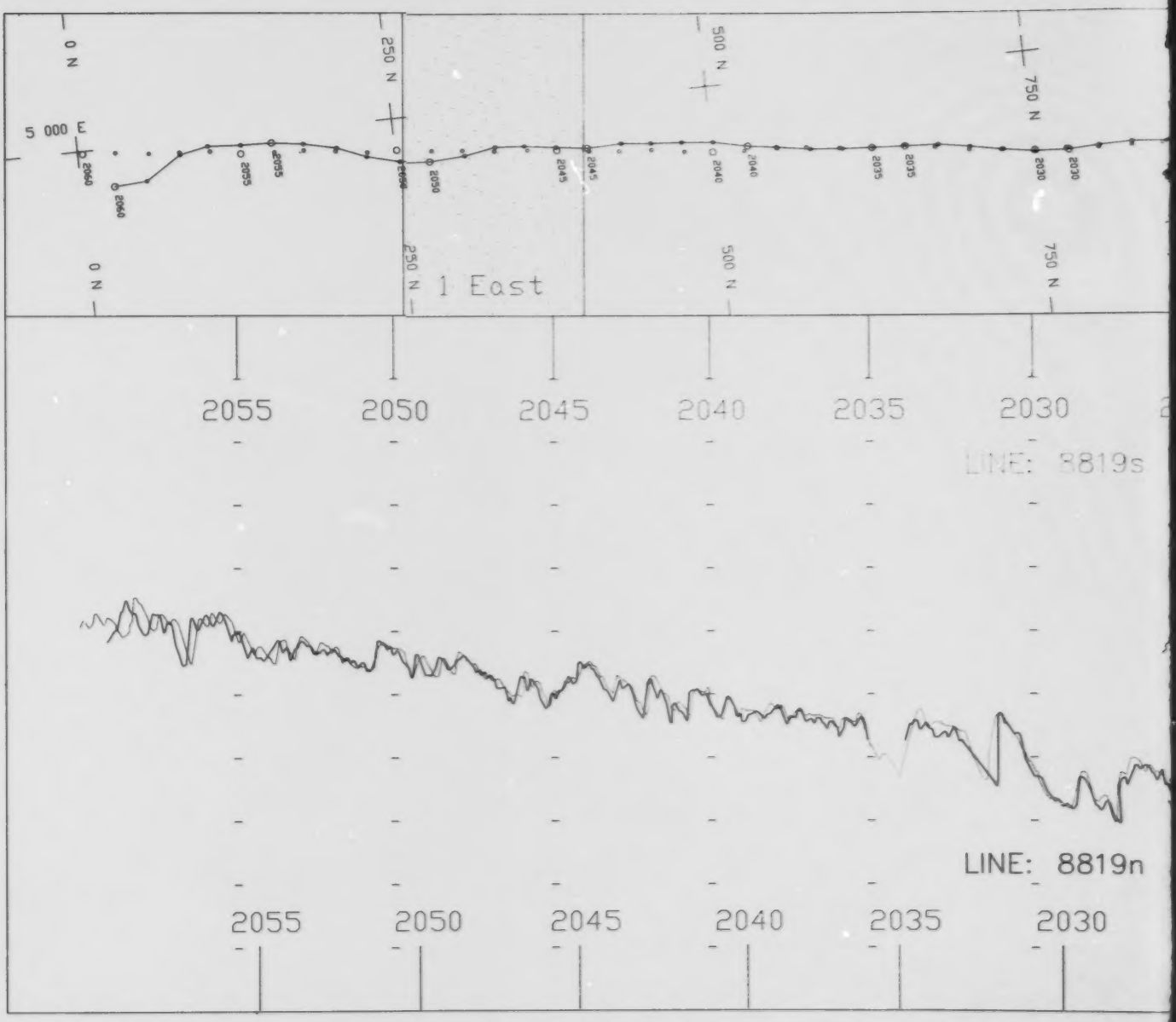

1 000 N
1 250 N
1 500 N
1 750 N
8813s (dotted)
8813n (solid)
5 000 E
N
2025
2020
2015
2010
2005
2000
8813s
8813n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8813s Track (thin)
8813n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8813S/8813N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
Prepared by: MacGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 16


0 N
250 N
500 N
750 N
5 000 E
2060
2055
2050
2045
2040
2035
2030
1 East
LINE: 8819s
LINE: 8819n

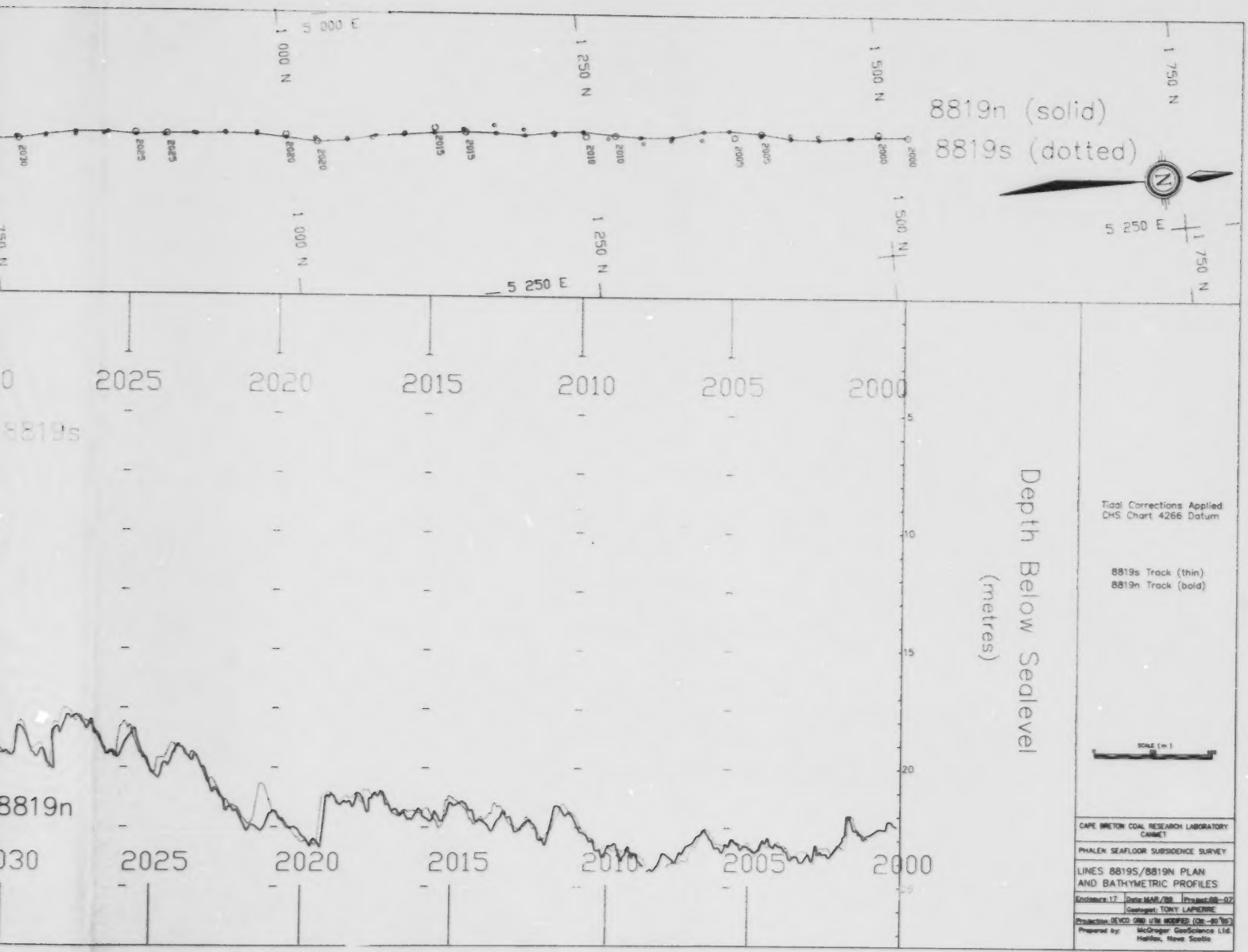
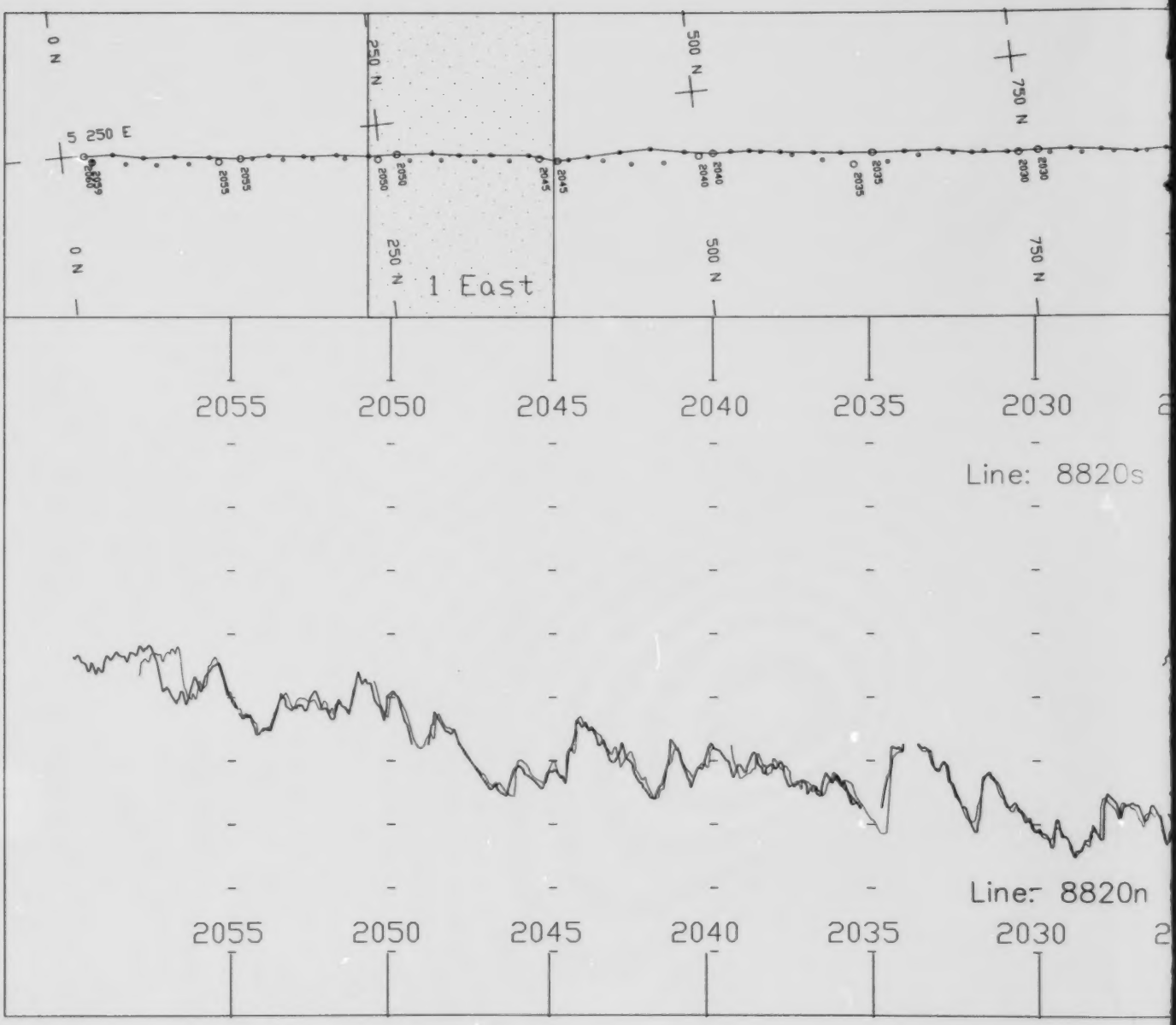

5 000 E
1 000 N
1 250 N
1 500 N
1 750 N
8819n (solid)
8819s (dotted)
5 250 E
2025
2020
2015
2010
2005
2000
8819s
8819n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8819s Track (thin)
8819n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8819S/8819N PLAN
AND BATHYMETRIC PROFILES
Enclosure 17
Date: MAR/98
Project: 98-07
Geologist: TONY LAPIERRE
Projection: DEVCO GRID (TM MODIFIED (Oo -60°W))
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 17


0 N
250 N
500 N
750 N
5 250 E
2055
2050
2045
2040
2035
2030
1 East
Line: 8820s
Line: 8820n

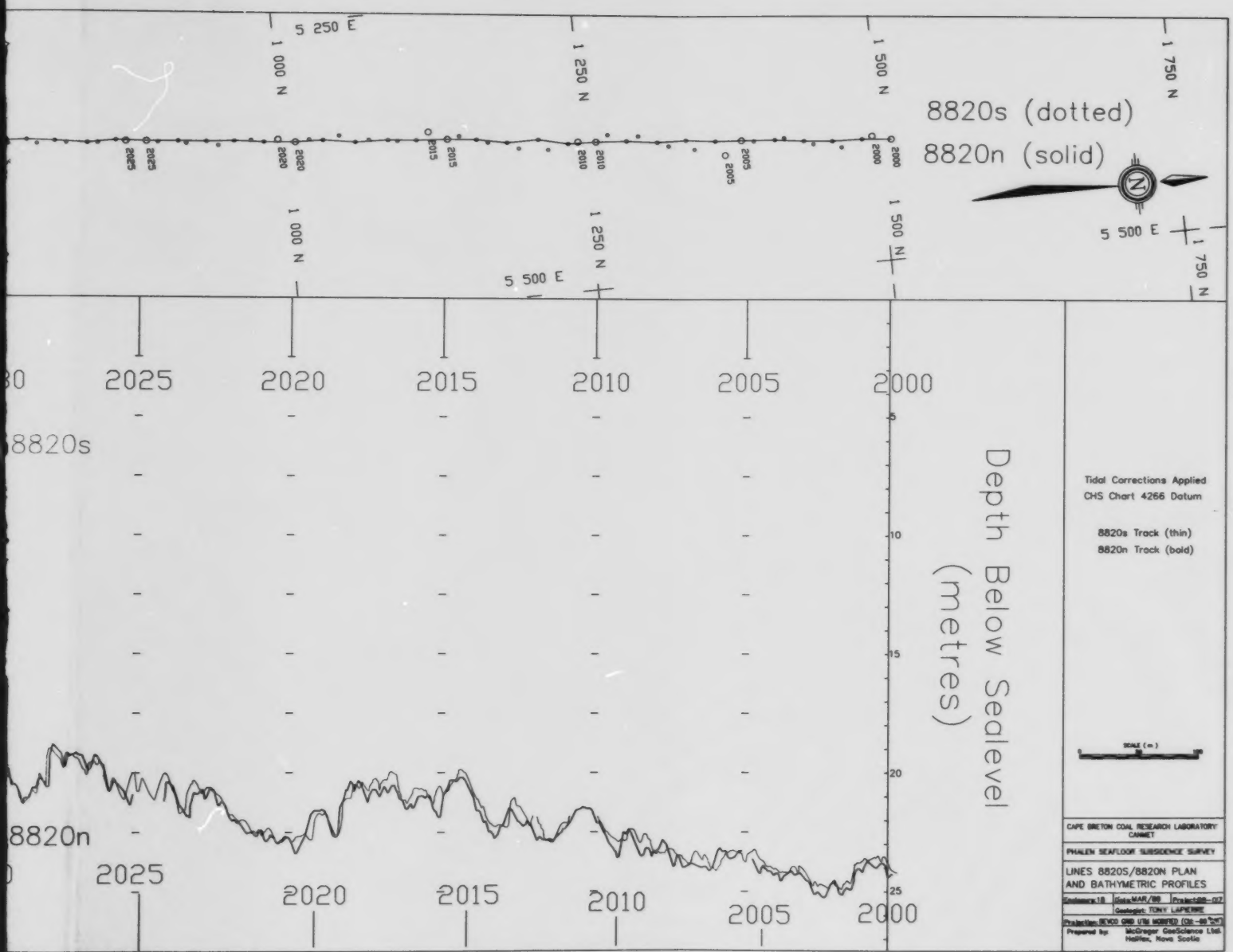
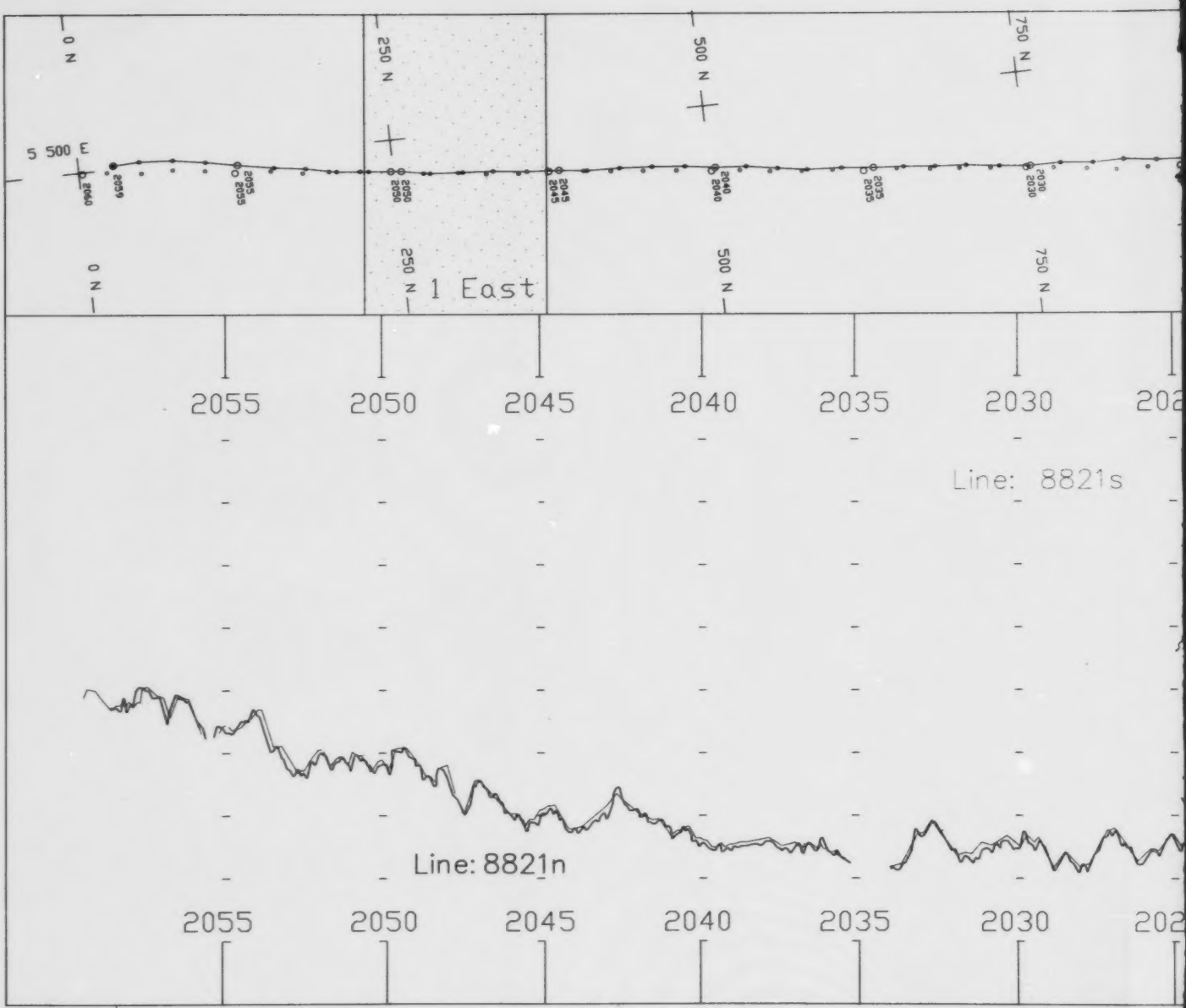

5 250 E
1 000 N
1 250 N
1 500 N
1 750 N
8820s (dotted)
8820n (solid)
5 500 E
2025
2020
2015
2010
2005
2000
8820s
8820n
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8820s Track (thin)
8820n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8820S/8820N PLAN
AND BATHYMETRIC PROFILES
Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

FIGURE 18


0 N
250 N
500 N
750 N
5 500 E
2060
2055
2050
2045
2040
2035
2030
1 East
Line: 8821s
Line: 8821n

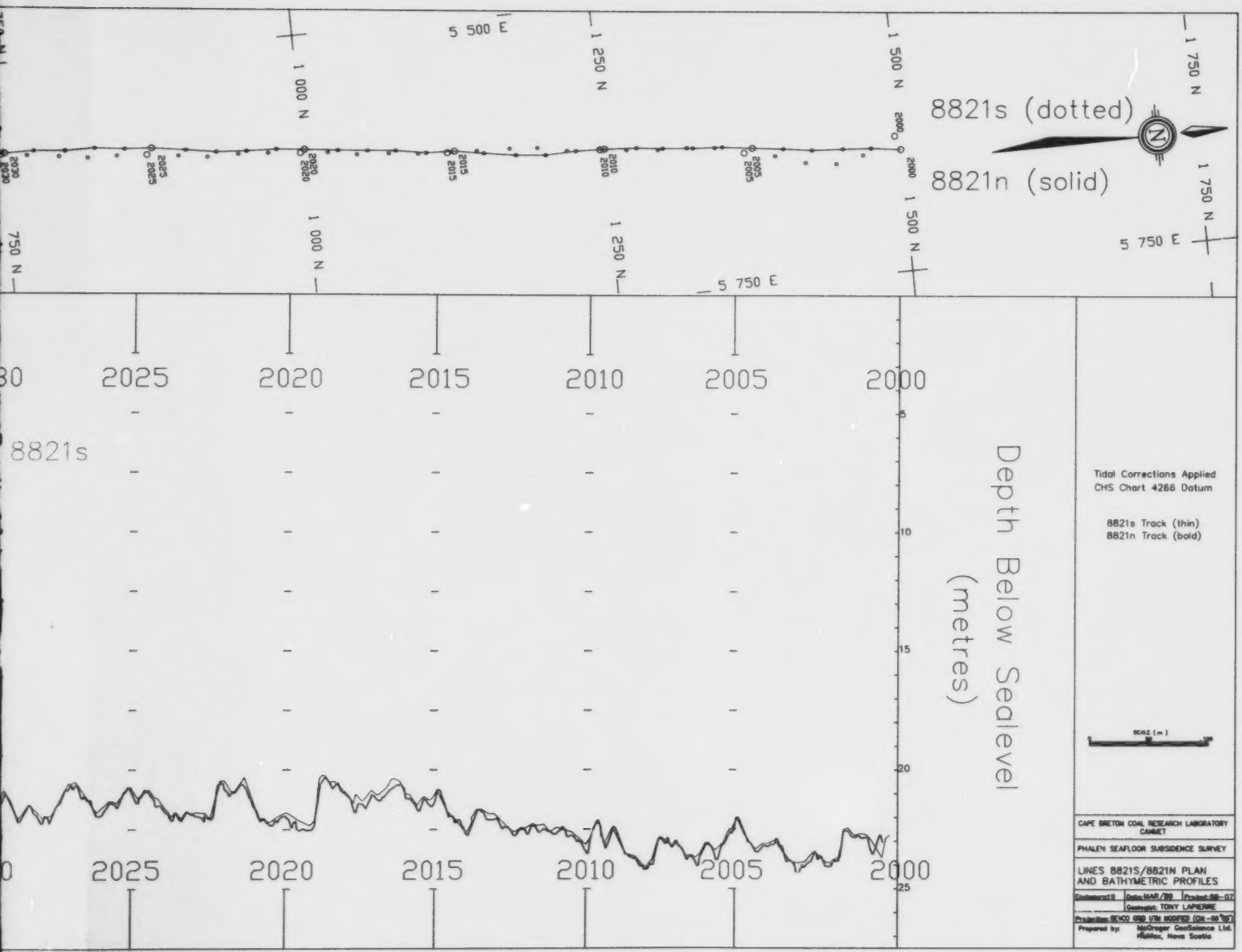

5 500 E
1 000 N
1 250 N
1 500 N
1 750 N
5 750 E
8821s (dotted)
8821n (solid)
2030
2025
2020
2015
2010
2005
2000
8821s
Depth Below Sealevel
(metres)
Tidal Corrections Applied
CHS Chart 4266 Datum
8821s Track (thin)
8821n Track (bold)
CAPE BRETON COAL RESEARCH LABORATORY
CANMET
PHALEN SEAFLOOR SUBSIDENCE SURVEY
LINES 8821S/8821N PLAN
AND BATHYMETRIC PROFILES
Geologist: TONY LAPIERRE
MacGregor GeoScience Ltd.

FIGURE 19

SECTION 3

RESULTS

3.1 The 1988 Topographic Profiles

The topographic profiles recorded in 1988 show excellent correlation between individual line pairs after adjustment for horizontal offsets resulting from differing total line lengths. These profiles are compared below with the original 1987 profiles in areas of the Phalen No. 1 East and No. 1 West longwall panels. The 1988 profiles are also intended as baseline data to compare with future survey lines.

3.2 Comparison of 1988 and 1987 Profiles

A comparison of profiles which lie above longwall panels mined between the time of the 1987 and 1988 surveys was completed to evaluate potential subsidence.

Subsidence, at the seafloor, probably does not develop immediately after mine face advancement. Therefore subsidence is most likely to be detectable on profiles acquired over panels mined immediately following the survey of 1987. The topographic profile across the Phalen No. 1 West panel on line 6 provides the best candidate for subsidence as the maximum amount of time has past between mining and post-mining surveying.

The amount of subsidence is expected to be less where less time has passed between mining and post-mining surveying. The following lines, listed in the order of decreasing time between mining and post-mining surveying, are expected to show subsidence.

Phalen No. 1 West	Phalen No. 1 East
Line 6	Line 13
Line 5	Line 14
Line 4	
Line 3	

All other lines represent areas not yet mined or surveyed prior to mining. Therefore no mining-induced subsidence is possible on any lines other than lines 3, 4, 5, 6 and 13 and 14.

The composite 1987 and 1988 track plot is presented as Figure 20. The superimposed 1987 and 1988 profiles, Figures 21 thru 28, illustrate anomalous depressions in the 1988 profiles. These depressions are restricted to the lines expected to show subsidence and occur above the Phalen No. 1 West and East longwall panels. The axis of these depressions (subsidence profiles) are offset downdip of the mined seam with depression profiles skewed. This assymetry is attributed to the mine seam dip.

The magnitude of subsidence is summarized in Table 1. The theoretical correlation of increased time between mining and post-

mining surveying and increased subsidence is not observed in the results presented in Table 1. This may be due to a more complex subsidence history resulting from variations in host rock physical properties and structural attitude.

Even with these limitations this project has provided the first observation and documentation of mining-induced subsidence at the seafloor above the Phalen Colliery.

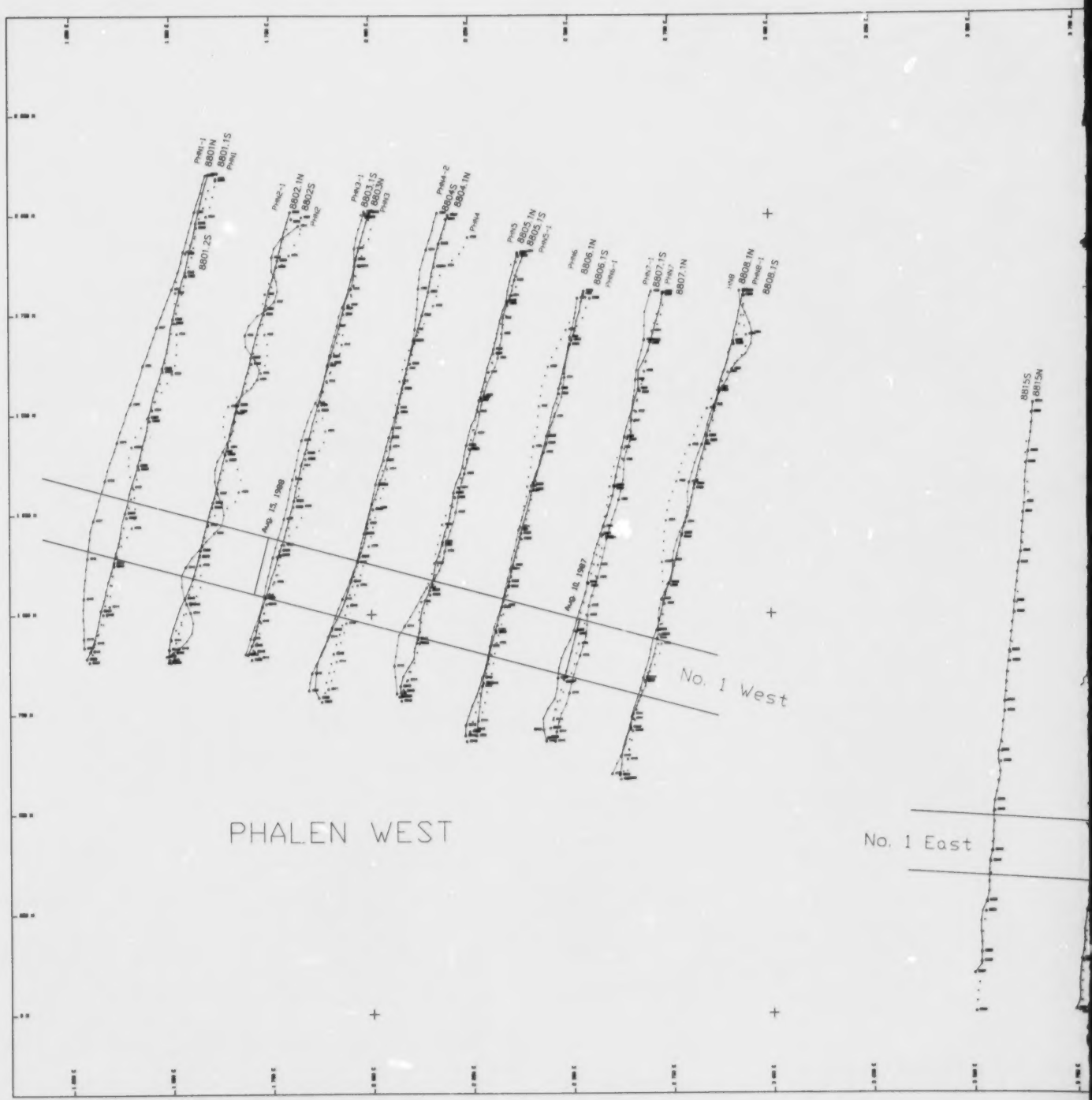
It is recommended that additional survey lines be acquired to repeat the grid of 1988 data over the Phalen No. 1 and No. 2 West and Phalen No. 1 and No. 2 East longwalls as mining progresses.

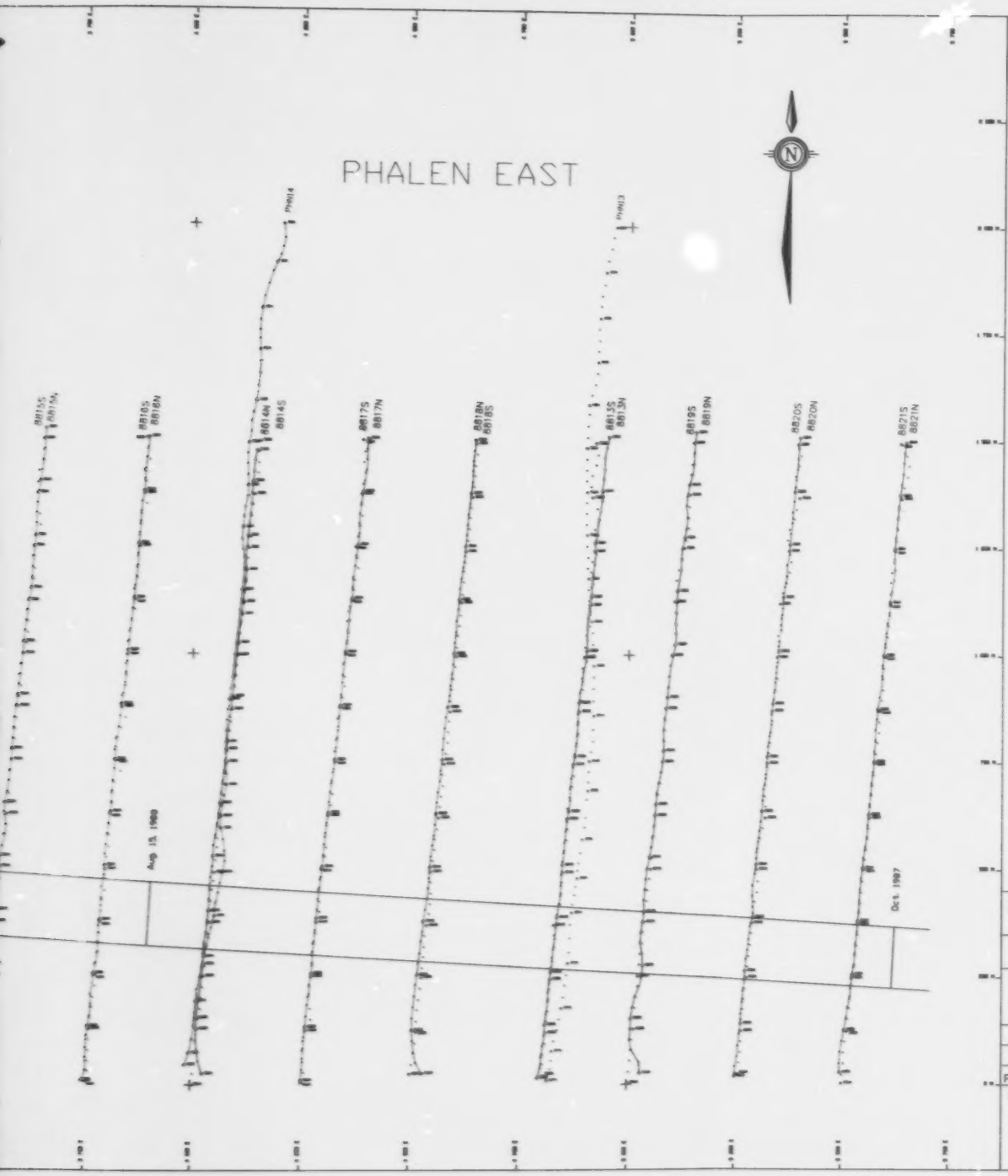
New survey data would probably provide evidence of additional subsidence profiles and increase the statistical validity of the current subsidence observations. These data could be used to further define the degree and timing of mining induced subsidence above the Phalen Colliery.

Table 1

Comparison of 1987 and 1988 Profiles

Line No.	1987 Pre/Post Mining	1988 Pre/Post Mining	Subsidence	Comment
01	Pre	Pre	N/A	No subsidence expected.
02	Pre	Pre	N/A	No subsidence expected.
03	Pre	Post	0	
04	Pre	Post	~1.0 m	
05	Pre	Post	0.8 m	
06	Pre	Post	0.5 m	
07	Pre	Post	0.3 m	Mining approximately coincident with '87 survey.
08	Post	Post	N/A	
13	Pre	Post	?	Only 1 1987 line.
14	Pre	Post	~0.8 m	Only 1 1987 line.


PHALEN WEST
No. 1 West
No. 1 East
Aug. 13, 1988
Aug. 10, 1987



LEGEND

Longwall Panel Mined From August '87

Longwall Panel Planned

PH04-2 — Line PH04-2 & 2 Track 1987

8804S — Line 8804S South Track 1988

8804.1N — Line 8804.1N North Track 1988

PH04 — Line PH04 #1 Track 1987

SCALE (m)

0 250 500

CAPE BRETON COAL RESEARCH LABORATORY
CANMET

SEAFLOOR SUBSIDENCE SURVEY

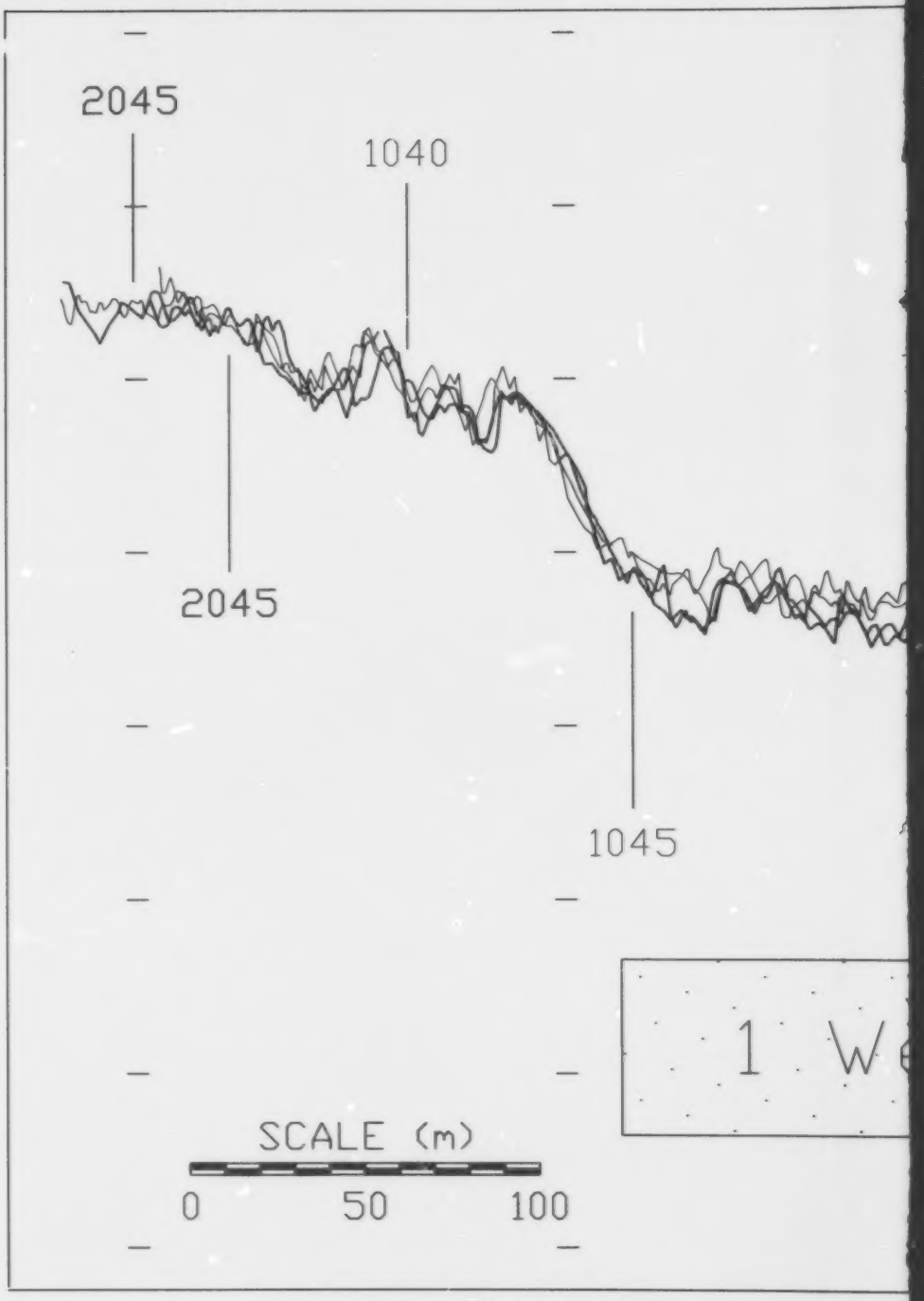
COMPOSITE TRACK PLOT 1987 & 1988
1987 and 1988 Surveys

Date: MAR. 89 | Project: 88-07

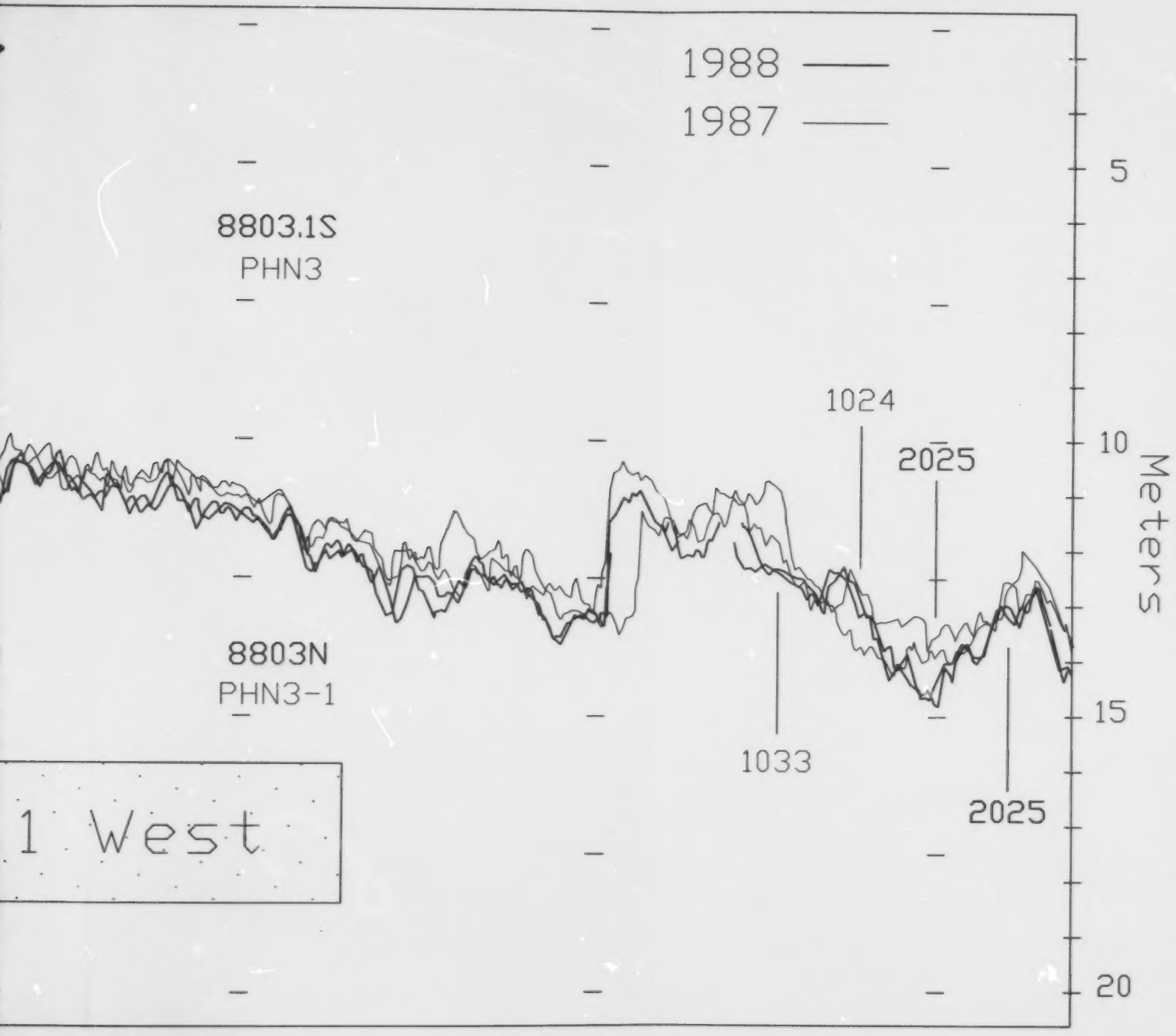
Projection: DEVCO GRID UTM MODIFIED (CM: -60°05')

Prepared by: McGregor GeoScience Ltd.
Halifax, Nova Scotia

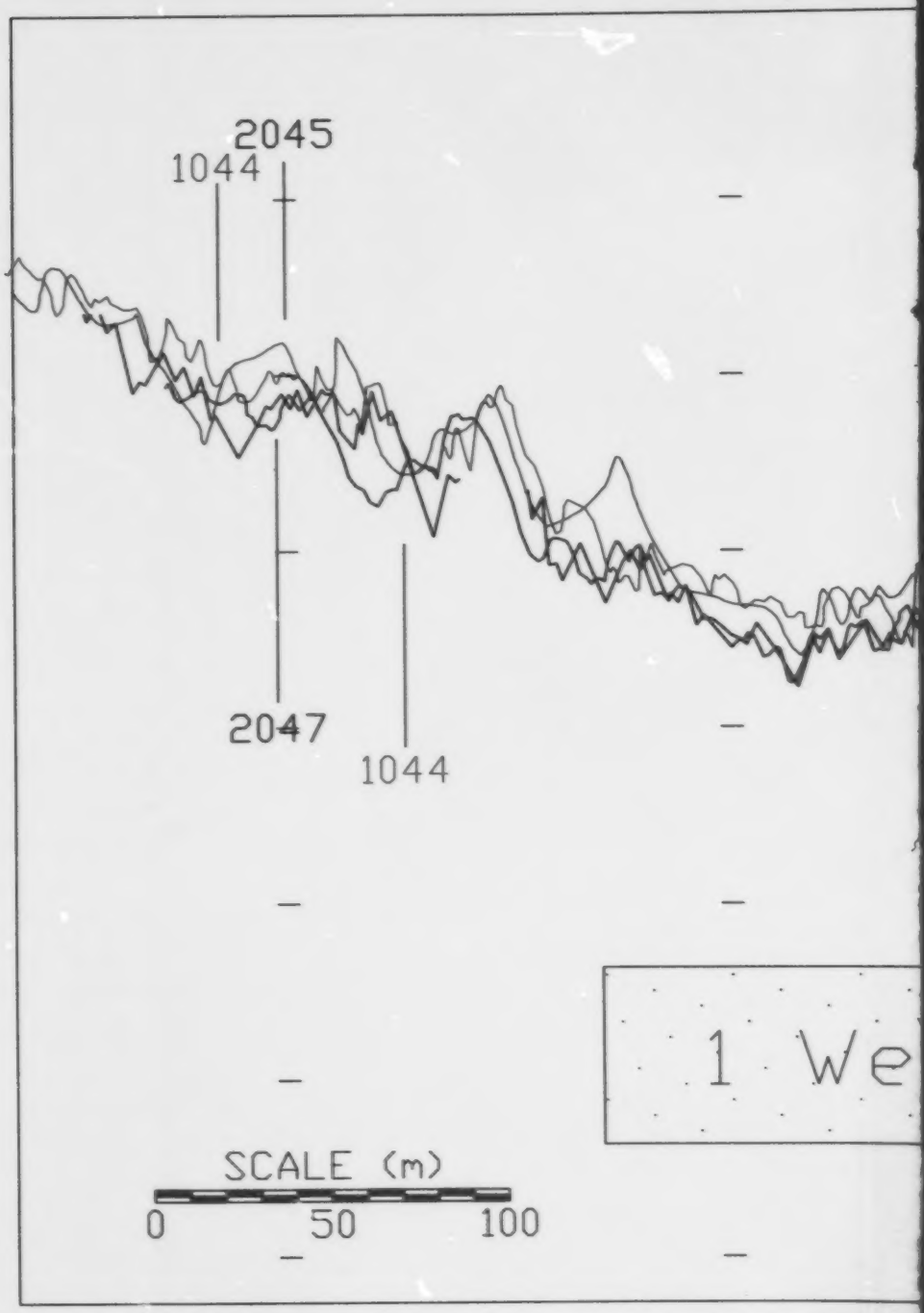
FIGURE 20



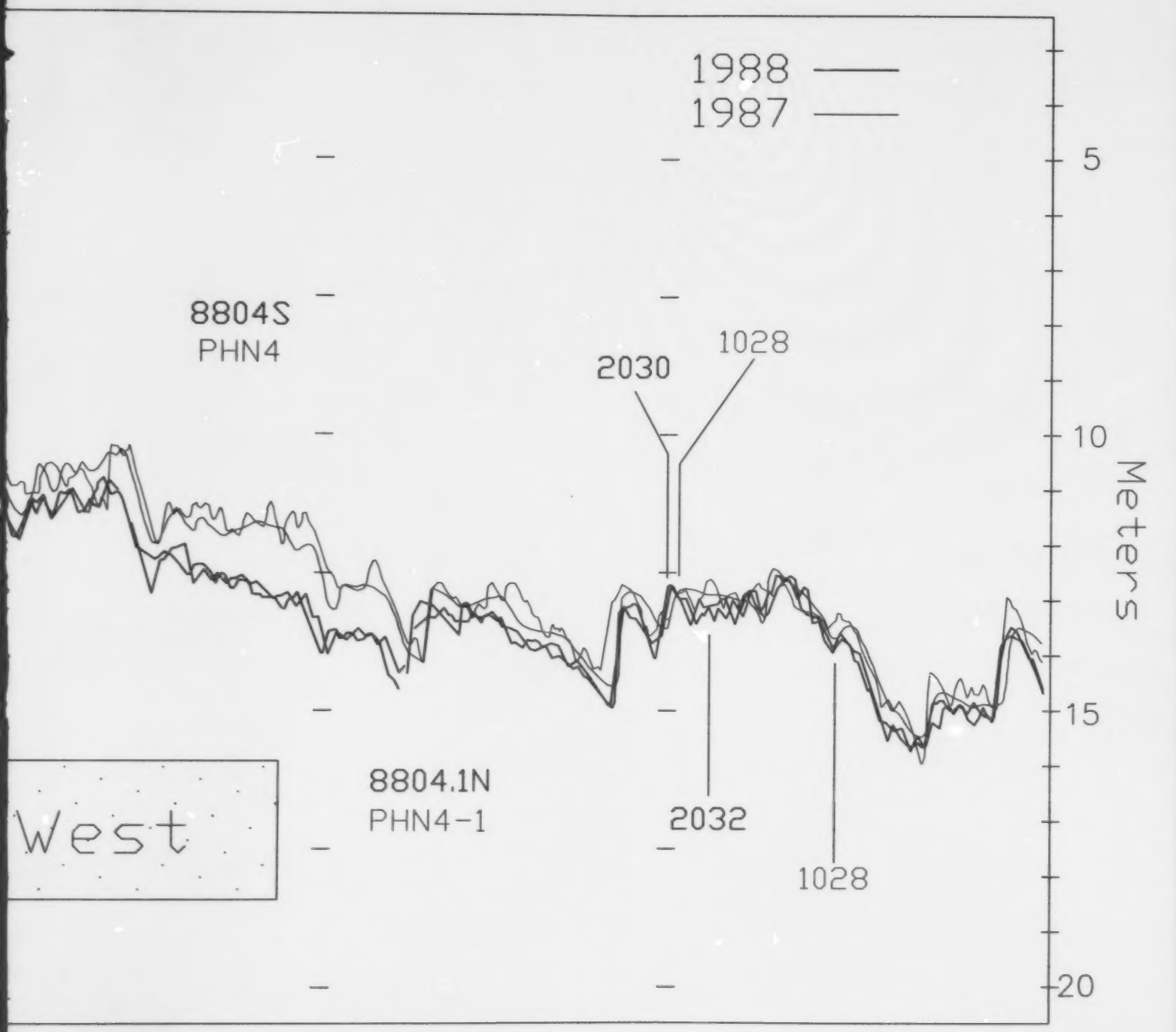
COMPOSITE PROFILES, 19



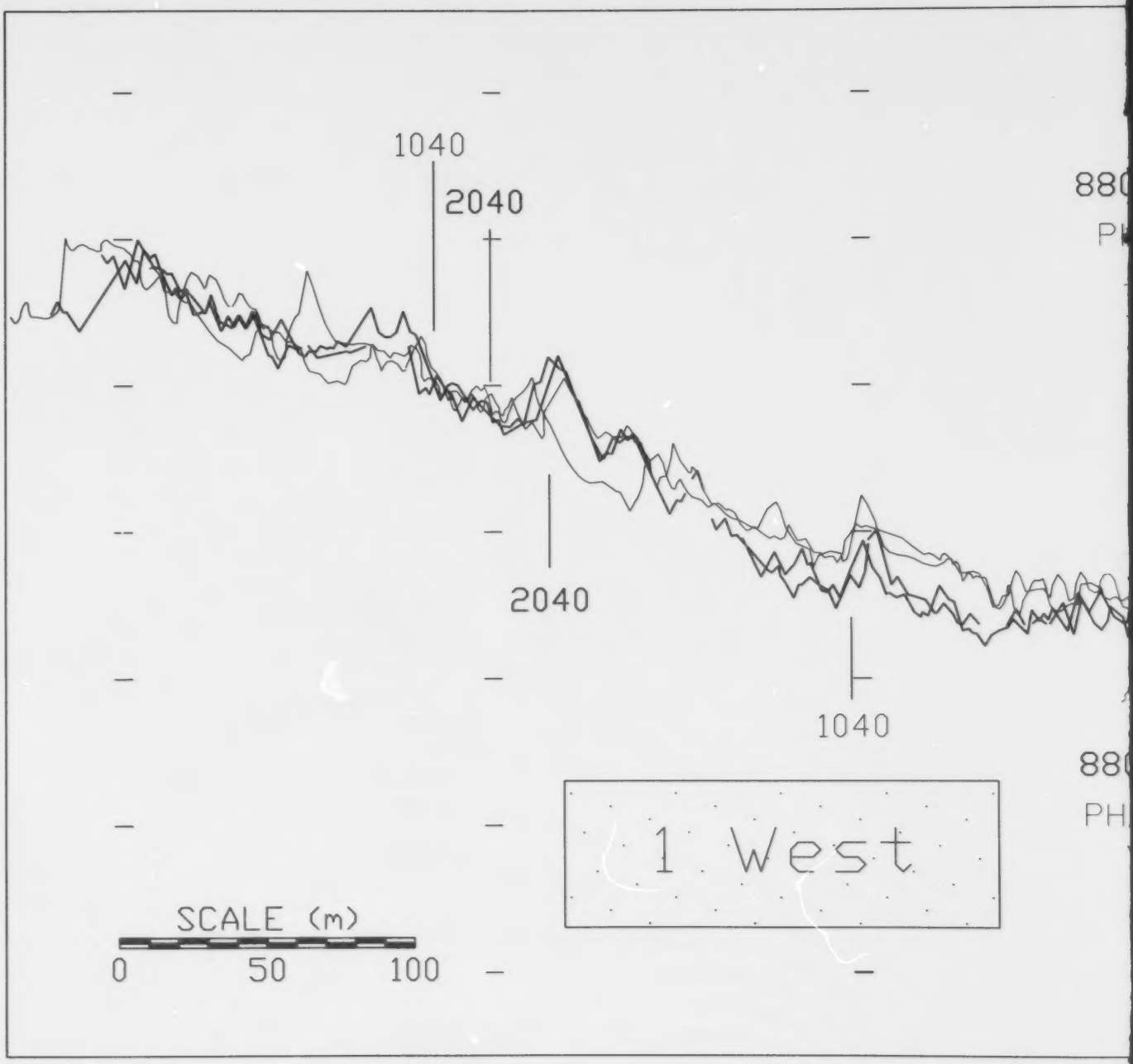
ES, 1988 AND 1987 - LINE 03 FIGURE 21



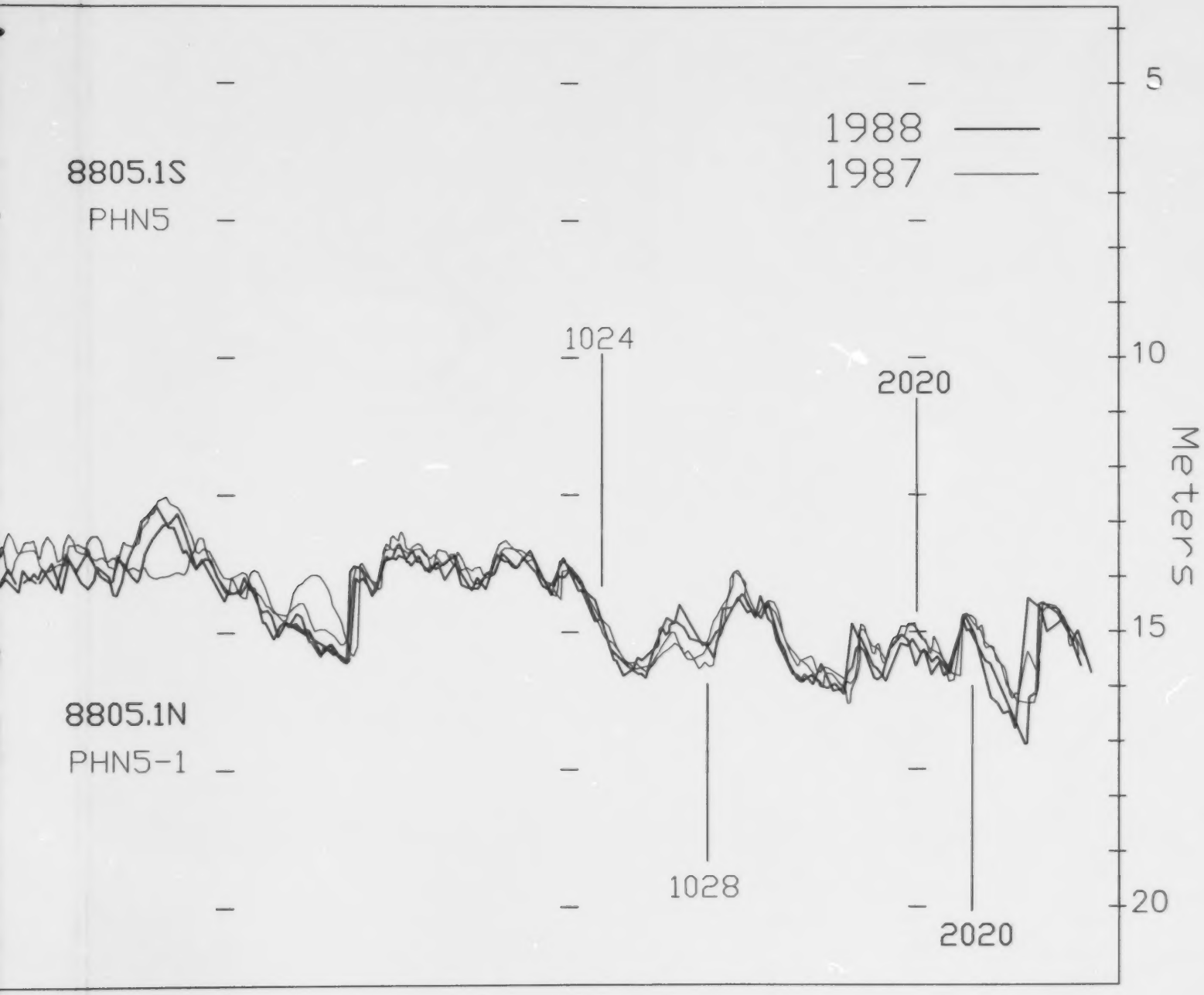
COMPOSITE PROFILES, 19



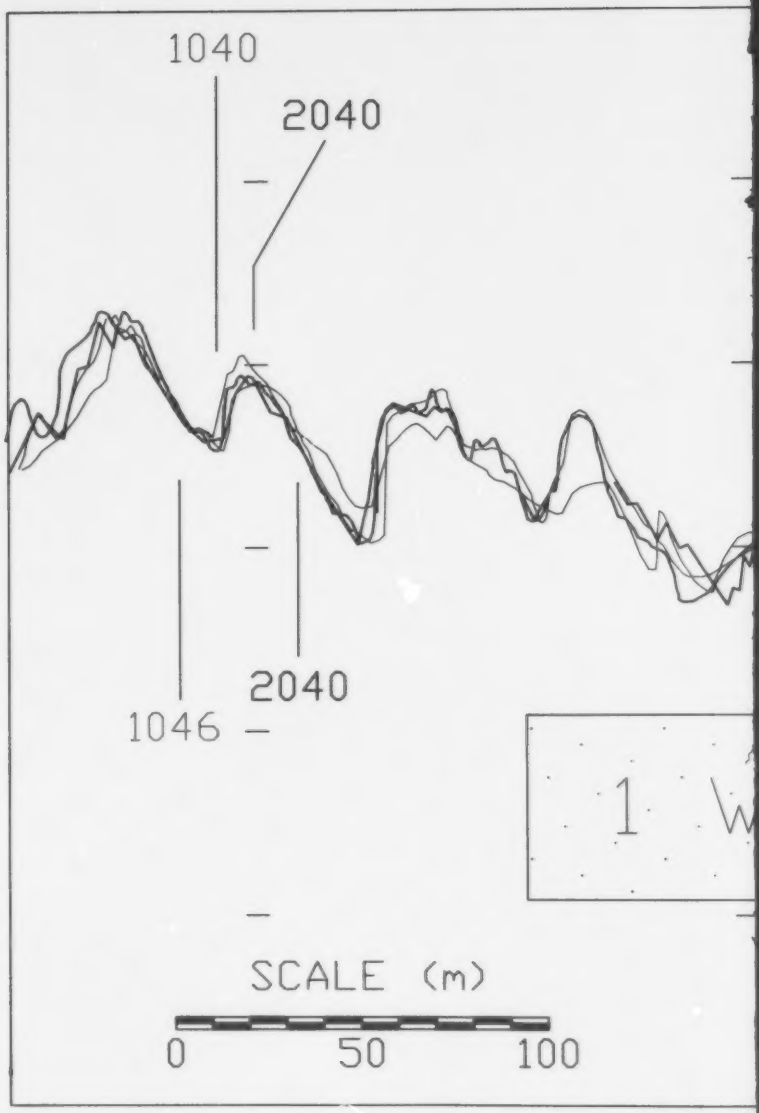
, 1988 AND 1987 - LINE 04. FIGURE 22



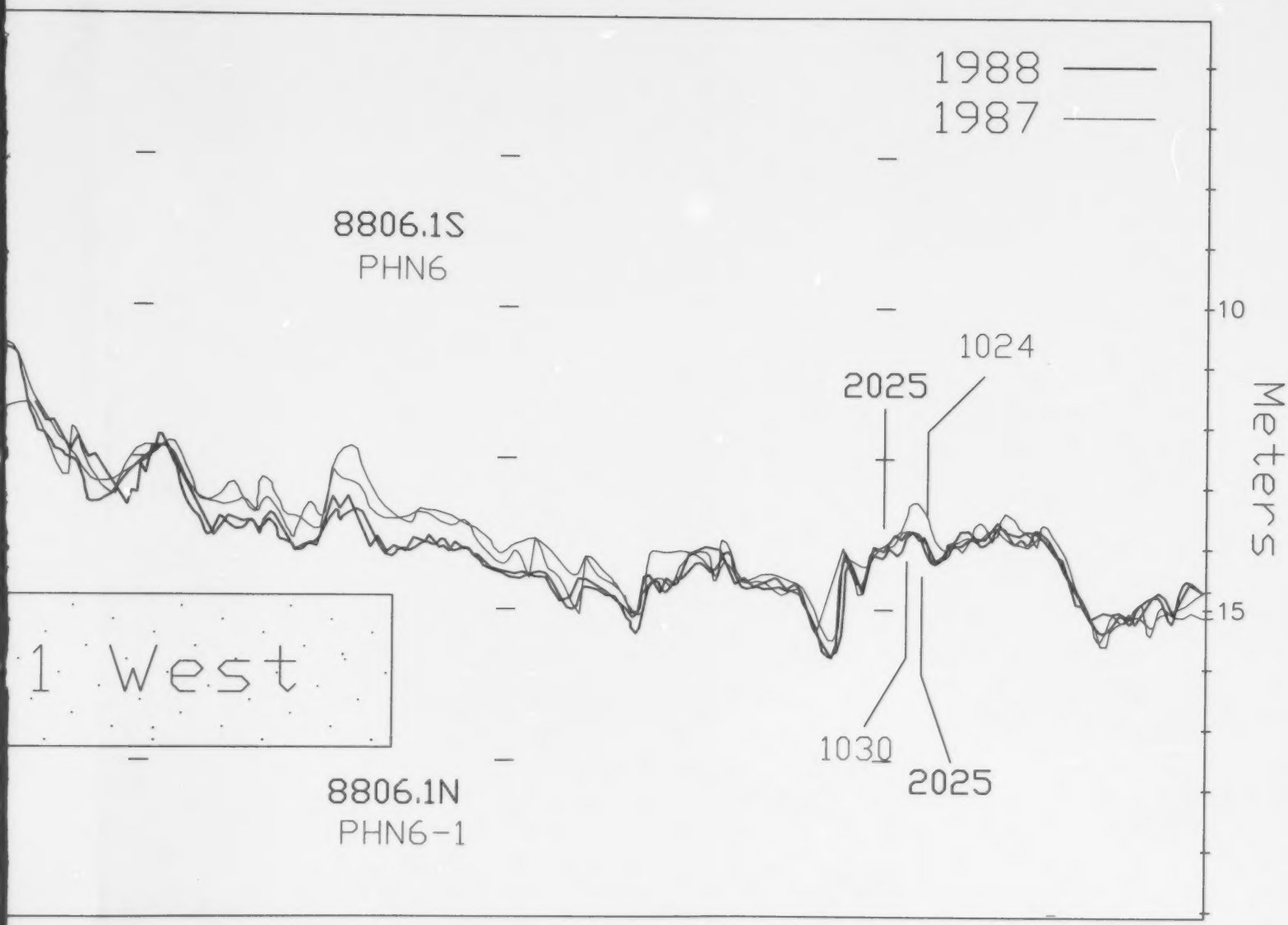
COMPOSITE PROFILES, 1988



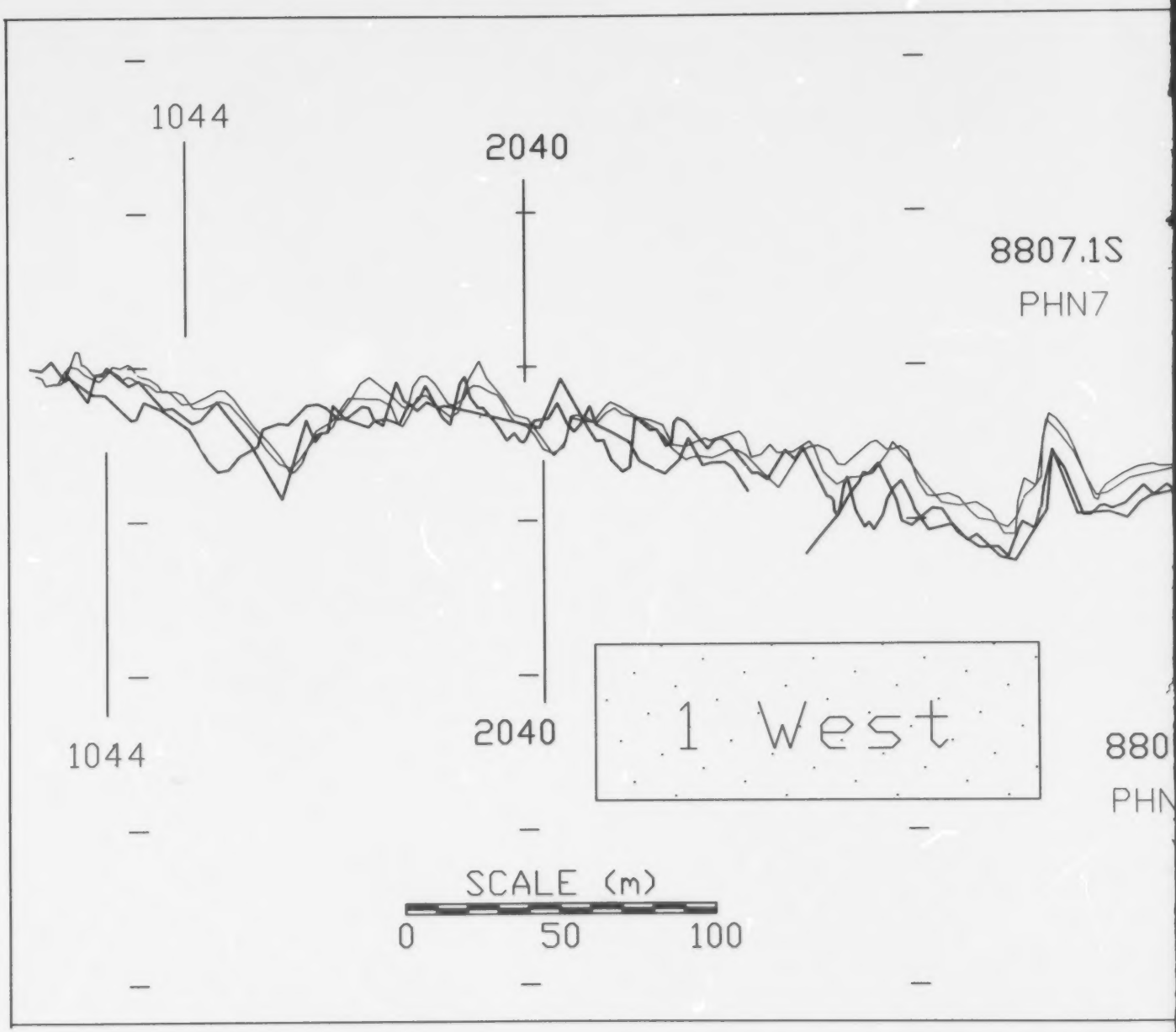
1988 AND 1987 - LINE 05. FIGURE 23



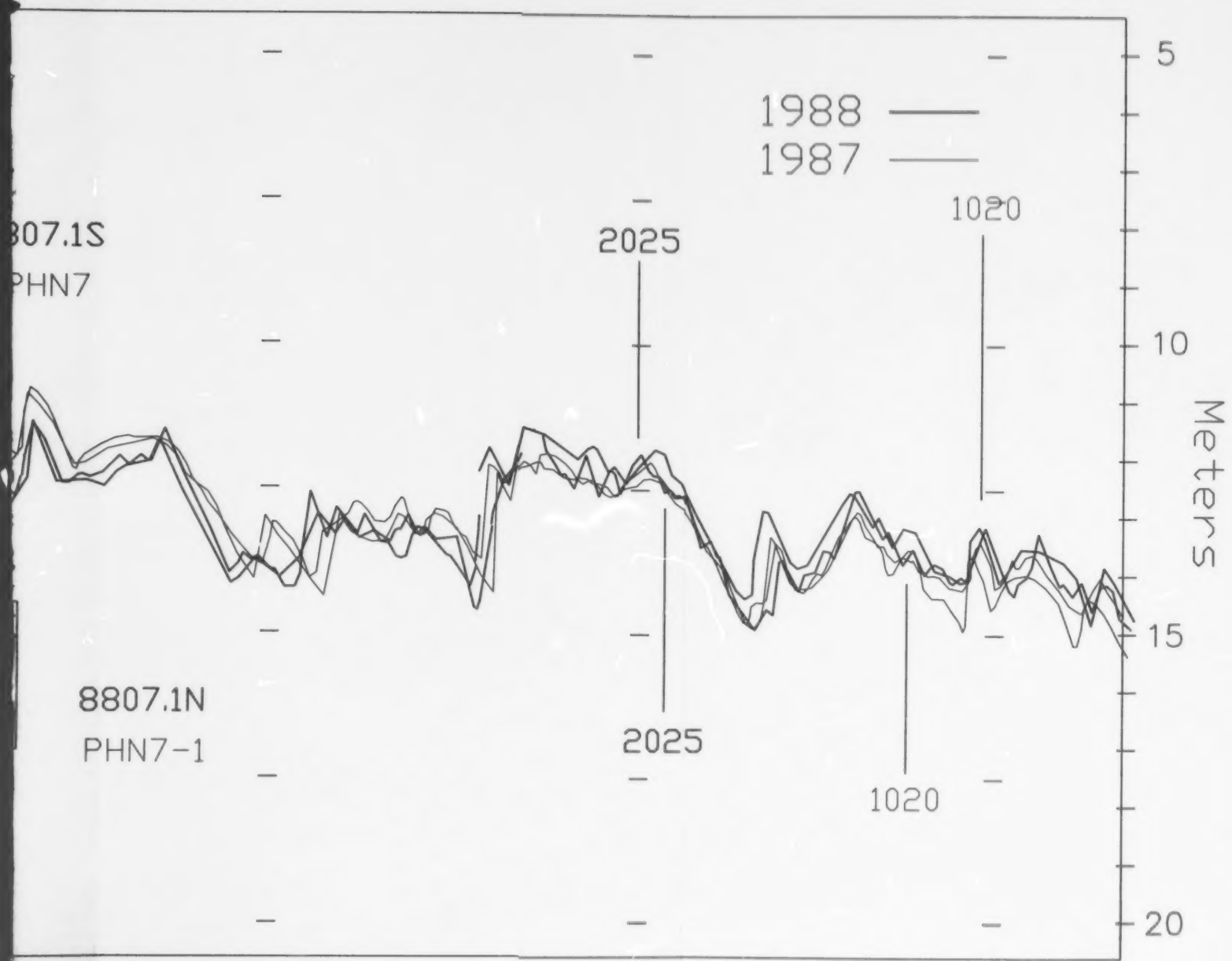
COMPOSITE PROFILES



FILES, 1988 AND 1987 - LINE 06. FIGURE 24

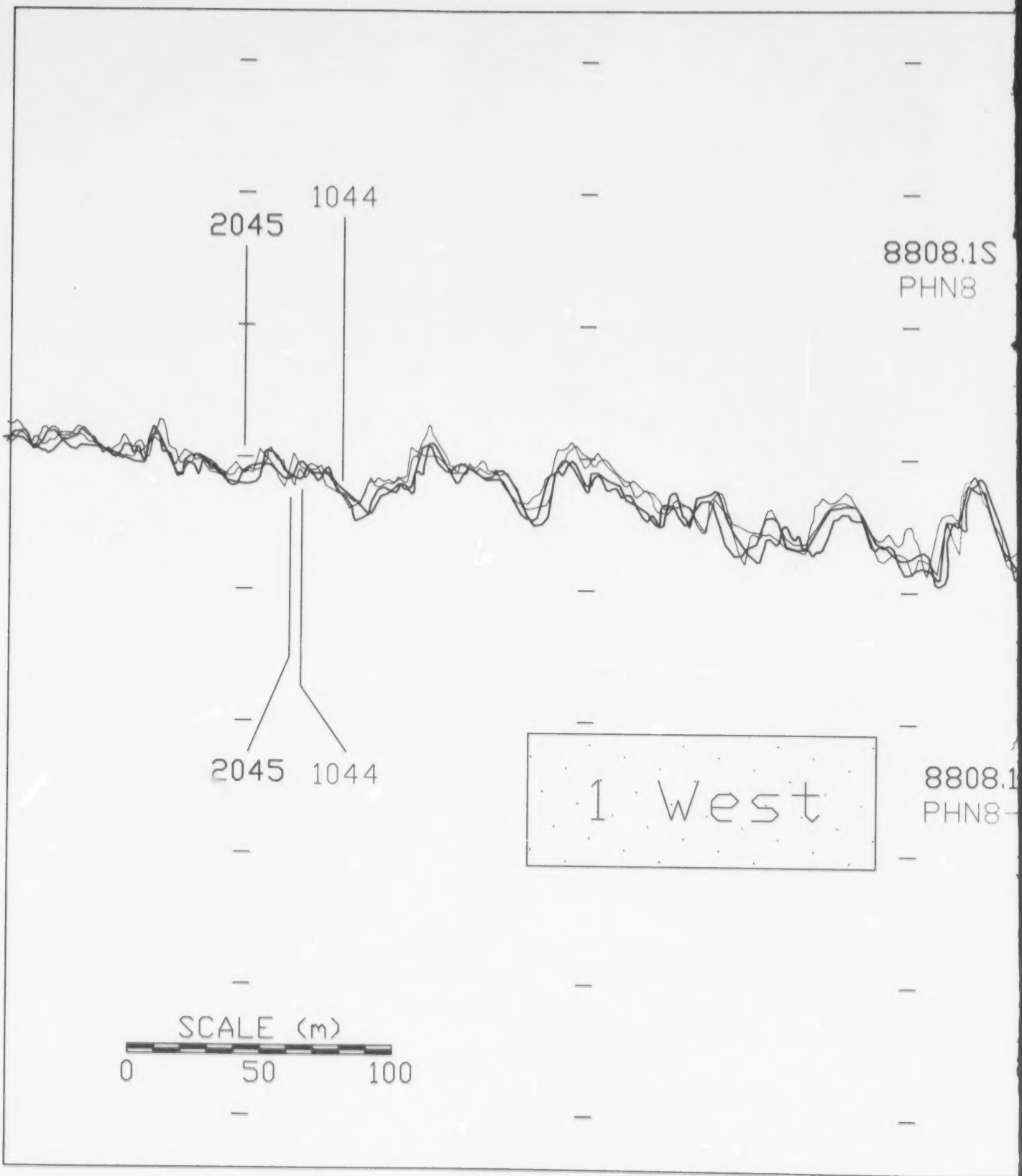


COMPOSITE PROFILES, 1988 AND 1

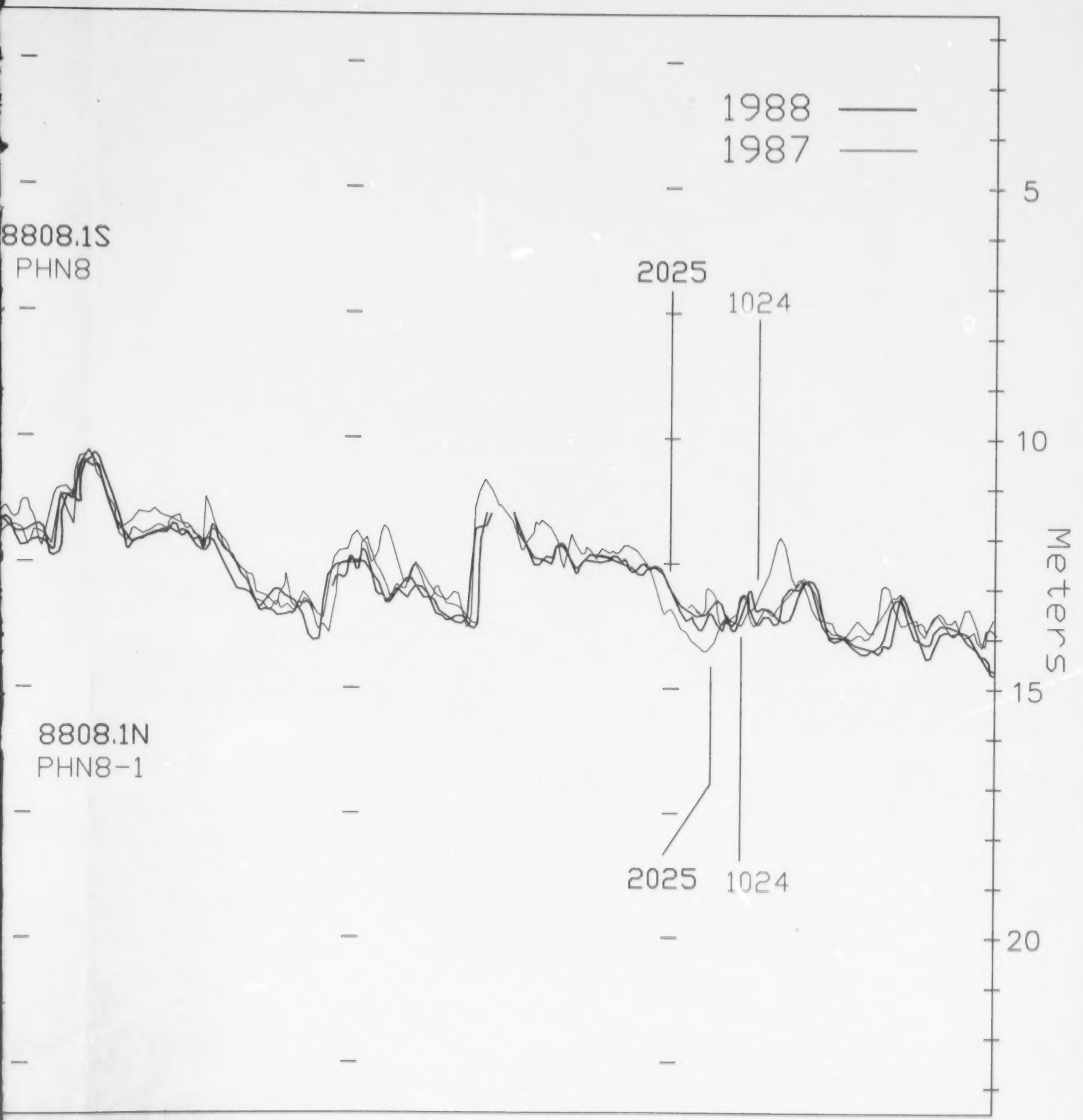


AND 1987 - LINE 07.

FIGURE 25

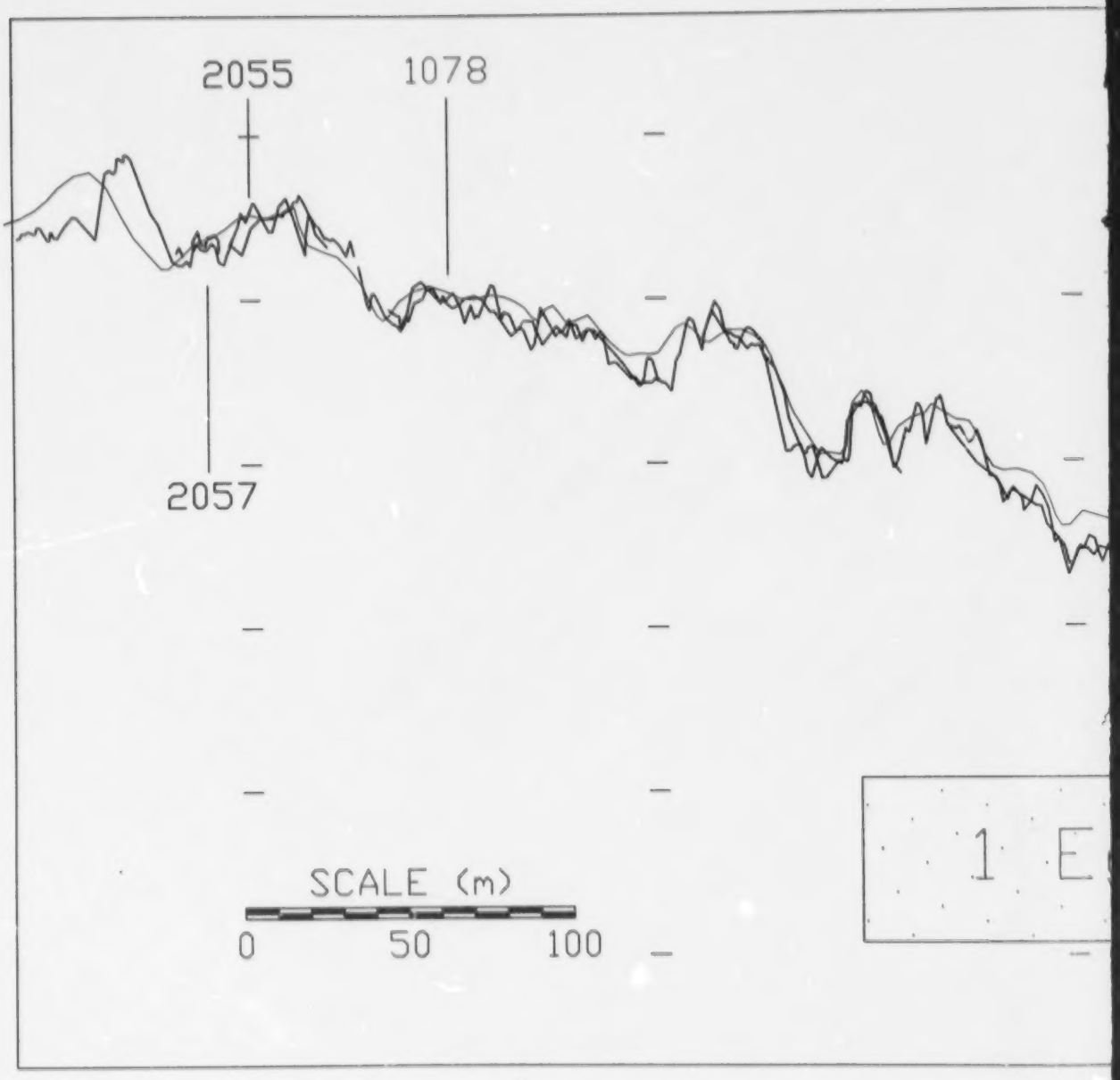


COMPOSITE PROFILES, 1988 AND

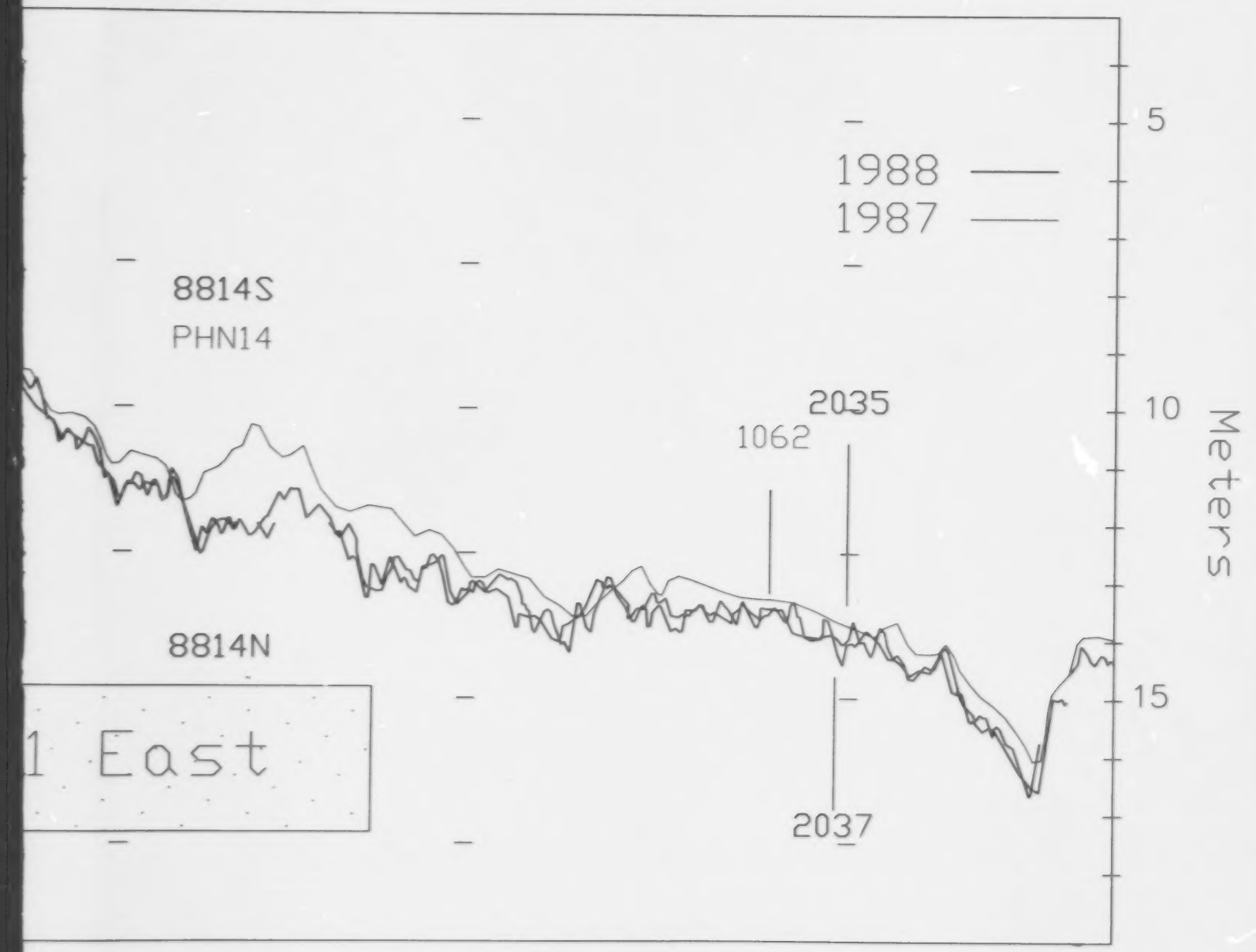


AND 1987 - LINE 08.

FIGURE 26

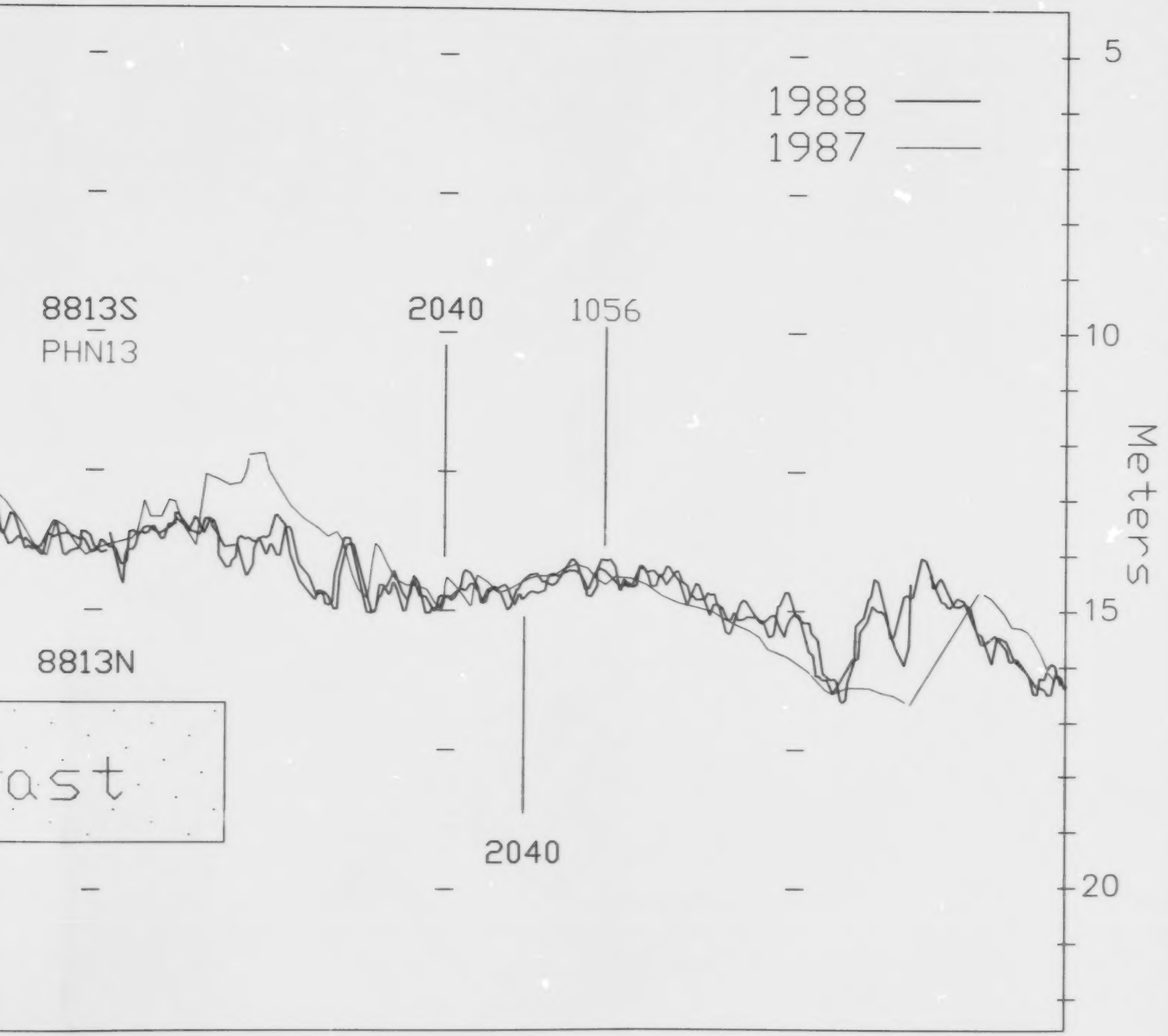


COMPOSITE PROFILES, 1988 AN



88 AND 1987 - LINE 14. FIGURE 27

COMPOSITE PROFILES, 1988 A



88 AND 1987 - LINE 13.

FIGURE 28

3.3 1988 Subbottom Profiles

The 3.5 kHz Profiler data indicated that the seafloor has no cover of soft sediments which might be mobile and which might migrate into a subsidence depression to obscure it. It should be pointed out that the system is inherently incapable, because of the relatively high frequency of its energy, of penetrating well-sorted sands and gravels. There is little doubt that outcropping rock and rock fragments occupy most of the seafloor. It is likely that there are small pockets of gravel and sand in depressions on the bedrock surface but the very irregularity of the bedrock surface would retard sediment mobility.

APPENDIX 1

OPERATIONS LOG

APPENDIX 1

OPERATIONS LOG

Time (Local)	Activity
	August 16, 1988
	Personnel and equipment drive Halifax to Sydney.
	August 17, 1988
	Completed mobiliztion of M/V IDLE OARS II at Big Bras D'Or. High wind precluded vessel leaving harbour.
	August 18, 1988
	Vessel sailed to government wharf, South Bar. Wind and sea too high to survey. Stewart and Powell scouted transponder control points and returned to South Bar at 1100 hours. Decision made to suspend operations for the day.
	August 19, 1988
0700	Stewart and Powell set up Low Point Lighhouse transponder, observed sea conditions and returned to South Bar. 0745 Vessel departed South Bar to test equipment and sea conditions. 0845 Off Low Pont; equipment testing. Determined sea too rough to gather good data.
1010	Returned to South Bar and suspended operations for the day due to weather.
	August 20, 1988
0700	Departed South Bar.
0800	Arrive site (West Phalen).
0845	Bar check completed(1494 m/s water velocity.
0922	Completed Line 8807; test line.

Time (Local)	Activity
	August 20, 1988 - Continued
0945	Commenced actual line survyed.
2115	Completed Line 8801.2 S - the last line of the day.
2125	Completed bar check and headed for South Bar.
2240	Arrived South Bar - end of day.
	August 21, 1988
0700	Departed South Bar wharf.
0815	Arrived at East Phalen site.
8825	Completed bar check; velocity unchanged. Draft of transducer unchanged at 0.5 metres.
0853	Commence surveying lines with Line 8815 south, seas calm.
1552	Completed last line of survey 8812 w.
1600	Completed bar check.
1605	Gear onboard - headed for Big Bras d'Or. Kevin Powell picked up transponders and delivered batteries to Coal Research Laboratory.
1800	Arrived Big Bras d'Or and commenced de-rigging the vessel.
	August 22, 1988
	Equipment and personnel return to Halifax.

APPENDIX 2

EQUIPMENT

APPENDIX 2

EQUIPMENT

A summary of the equipment employed in the Sydney geophysical survey is given below. Table 2-1 presents the configuration of the seismic, bathymetry and navigational systems.

2.1 Horizontal Control for Vessel

Details on navigation for the 1988 survey are given in Appendix 4. A Del Norte Trisponder, Model 540 was employed as the primary positioning system.

Four shore-based transponders and the computing software of McElhanney Surveys provided highly accurate positions for the survey vessel while on line. McElhanney's NAVPAK software in conjunction with a Hewlett Packard 9836 computer performed various functions:

a) record four range measurements
b) compute geographic position of the vessel
c) record ranges and positions at regular time or distance intervals (10 metre distance intervals for instance)
d) output event marks at regular time or distance intervals for marking of analogue profile records

e) provide line-steering guidance to the navigator via a monitor at the navigator's station and to the helmsman via a remote monitor.

The software employs least squares computation and Kalman Filtering techniques to optimize position fixing.

The tape-recorded positioning data to produce track plots following the survey, at a working scale of 1:5000.

The Del Norte Trisponder is a microwave system operating at a frequency of approximately 9400 MHz. The system provides positional accuracy of +/- 1 metre in ideal conditions. Two, 12 volt auto batteries provided 24 VDC to each of four transponders located along the shoreline near the survey area.

2.2 Horizontal Control Onshore

The four control points employed in the 1987 survey were again employed in the 1988 survey. These are located at

- No. 26 Colliery
- Lingan Airshaft
- LRIS Station No. 1614
- Low Point Lighthouse

Three of these stations (LRis NO. 1614 excepted) were marked by rebar stakes following the 1987 survey. All were recovered immediately except the Lingan Airshaft station. At this point, the rebar marker had been pulled out of the ground and displaced. We located the marker and replaced it in its original position.

2.3 Precision Echosounder

In consideration of the fact that the study was concerned about subsidence of less than 3 metres maximum, grading to no displacement at the extremities of the subsidence profile, a minimum of 400 metres apart, it was necessary to employ a high resolution, precision echosounder. The echosounder selected has the ability to vary paper transport rate and stylus sweep range so that good horizontal and vertical resolution of seafloor features can be realized.

This project utilized the ATLAS DESO-20 for precise recording of seafloor profiles. This system offers the following features:

- Simultaneous, dual frequency operation: 210 kHz and 33 kHz. The low frequency output component is capable of penetrating soft surficial sediments and so acts as a very high resolution, shallow subbottom profiler and seabed

classification system. The high frequency output component provides the highest resolution profile of the seafloor.

- digitization of water depth with LED display and output to navigation computer for permanent recording
- wide choice of vertical recording ranges permits choice of vertical scale to optimize resolution
- wide choice of paper transport speeds - adjustable in 10 steps from 12.0 to 0.015 mm/second permits selection of a horizontal scale to optimize resolution
- automatic annotation of recording parameters such as:
  - speed of sound in water (measured by bar check)
  - measuring range and phase
  - time and distance marks
- graphical precision at 210 kHz is +/- 0.12% of depth +/- 1.5 cm, using a narrow beam transducer (9 degrees).

We mounted the echosounder transducers on a gimballed over-the-side mount which compensated for modest vessel motion.

We calibrated the echosounder for draught of the transducers to be 55 cm and for speed of sound in sea water (by means of the hydrographic standard bar checking technique) to be 1494 m/s. This contrasts with a velocity of 1457 m/s measured in the 1987 survey.

Compensation of echosounding measurements for tidal changes was made using data from the North Sydney permanent tidal gauge (Table 2-2).

The ATLAS DESO-20's precision and flexible choice of recording scales permitted selection of optimum recording parameters for the purpose of pre- and post-subsidence profile comparison.

2.4 Subbottom Profiler System

We considered that some definition of surficial sediment thickness and buried bedrock surface would be beneficial in the baseline and subsequent surveys. This was necessary to ensure that subsidence of the stable bedrock surface would not be obscurred by sediment transport.

The Ferranti-O.R.E. Model 140 Subbottom Profiler system was employed for the recording of seismic profiles. This system is comprised of the following components:

A) a gimballed, over-the-side-mounted array of transducers which was operated at 3.5 kHz

B) a Transceiver - Mod. 140

We recorded the Subbottom Profiler records on an EPC 3200 graphic recorder.

The geophysical records acquired with this system are of good quality, however they display no penetration of the seafloor, indicating that sediments are not present or are too coarse and reflective to be penetrated.

From our 1987 and 1988 surveys, we conclude that sediment transport will not likely obscure subsidence profiles.

TABLE 2-1 CONFIGURATION OF SURVEY EQUIPMENT

Navigation Antenna to Vessel Centre Line	0.0 m
Navigation Antenna to Vessel's Side	1.9 m
Navigation Antenna to Vessel's Stern	8.5 m
Echosounder Astern of Navigation Antenna	4.0 m
Profiler Astern of Navigation Antenna	4.0 m
Echosounder to Vessel Centre Line	2.2 m (Port)
Profiler to Vessel Centre Line	2.2 m (Stbd)

NOTE: The Navigation Point for the vessel was taken to be the echosounder position and offsets were accounted for in the navigation software.

TABLE 2-2 HOURLY WATER LEVELS AND DAILY MEANS

NORTH SYDNEY TIDAL STATION AUGUST 20 AND 21, 1989

Time AST	Aug 20 Water Level	Aug 21 Water Level
0100	107 cm	113 cm
0200	101 cm	112 cm
0300	89 cm	99 cm
0400	73 cm	89 cm
0500	60 cm	79 cm
0600	50 cm	63 cm
0700	46 cm	58 cm
0800	52 cm	56 cm
0900	66 cm	60 cm
1000	73 cm	63 cm
1100	94 cm	80 cm
1200	97 cm	92 cm
1300	106 cm	99 cm
1400	99 cm	102 cm
1500	94 cm	107 cm
1600	85 cm	99 cm
1700	70 cm	92 cm
1800	65 cm	82 cm
1900	59 cm	77 cm
2000	64 cm	73 cm
2100	72 cm	80 cm
2200	82 cm	89 cm
2300	99 cm	107 cm
2400	105 cm	106 cm
Mean Height	80 cm	87 cm

NOTES: Data prepared by Marine Environmental Data Service, Ottawa

Data is "provisional"

Water level heights are referenced to Canadian Hydrographic Service Chart Datum for the newly released Chart 4266. Note that the chart datum for the 1987 survey referred to charts 4315 and 4367. The 1988 datum has been raised by 28 cm thus 1988 depth profiles are inherently deeper by 28 cm than the 1987 profiles

APPENDIX 3

PERSONNEL

APPENDIX 3

PERSONNEL

FIELD PERSONNEL

McGregor GeoScience Limited acted as prime contractor for the survey. Direct contractal obligations included overall quality control during the survey, collection of geophysical and bathymetric data and the interpretation of the collected data.

Project Manager	John Stewart
Geophysical Operator	Damien Kimball
Navigator	Ben Couturier
Navigation Assistant	Kevin Powell
Vessel's Skipper	Stewart Squires

INTERPRETATION PERSONNEL

McGregor personnel completed the data processing, interpretation and report.

John Stewart acted as both the project manager and as a contributing marine geologist.

Tony LaPierre, a marine geologist, guided the data processing and plan/profile development in AutoCad.

Steve Hart, a marine geologist, handled much of the data input and file conversion and shared the processing task in AutoCad with David Swaine.

APPENDIX 4

NAVIGATION REPORT

PHALEN MINES SUBSIDENCE STUDY - 1988
POSITIONING REPORT

JOB #20600278

SUBMITTED TO:

McGREGOR GEOSCIENCE LIMITED

1959 Upper Water Street, Suite 507
Halifax, Nova Scotia
B3J 3N2

SUBMITTED BY:

McELHANNEY SERVICES LIMITED

101 Thornhill Drive, Suite 1
Dartmouth, Nova Scotia
B3B 1S2

AUGUST, 1988

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2.1	Software	2
2.2	Navigation System	2
2.3	Shore Control	3
2.4	CBCD Local Grid	3
3.0	LINE COORDINATES	4
4.0	CONCLUSIONS	6

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1	SHORE CONTROL COORDINATES	3
2	LINE COORDINATES	4

LIST OF ENCLOSURES

ENCLOSURE NO.	
1	PHALEN MINES SUBSIDENCE STUDY - 1988 NORTH AND EAST LINES
2	PHALEN MINES SUBSIDENCE STUDY - 1988 SOUTH AND WEST LINES

1.0 INTRODUCTION

McElhanney Services Ltd., under contract to McGregor GeoSciences Ltd., provided positioning for the Phalen Mines 1988 Subsidence Study, located near New Waterford, cape Breton.

This report presents the results and outlines the positioning services provided.

2.0 POSITIONING

Positions of the soundings were acquired using McElhanney's navigation software NAVPAK in conjunction with the Del Norte Trisponder System. Offset corrections between the Trisponder antenna and the transducer were applied within the software to obtain sounding positions as opposed to antenna positions. The Trisponder equipment was calibrated on a 5.6 km baseline established between Dartmouth and Halifax. Positioning accuracy of the system is +/- 3 metres at the standard error ellipse level.

2.1 Software

NAVPAK is an integrated positioning/navigation system. The software supports various devices for real-time navigation, data collection, post-processing and presentation. This program has been developed in-house by McElhanney and represents over 10 years of ongoing development.

Positions are available either in geographic, UTM, or plane coordinates derived from a weighted least square solution. Further details concerning NAVPAK can be obtained from McElhanney Services Limited in Dartmouth, Nova Scotia.

2.2 Navigation System

The Del Norte Trisponder system was utilized for this project. Trisponder is a microwave ranging system which operates at line of sight ranges. The DDMU (mobile unit) interrogates each shore station sequentially and receives a reply signal from each. The ranges can be deskewed to a common time and predicted when the ship is on a constant course and speed. The range information is either available as raw range or smoothed (filtered) range.

The resolution of one range is 0.1 metre; the accuracy of a range is typically +/- 1 to 2 metres.

2.3 Shore Control

The Trisponder equipment was installed on 4 control points defined on the CBCD local grid. The following table lists the shore control coordinates.

TABLE 1

SHORE CONTROL COORDINATES

STATION NAME	NORTHING (metres)	EASTING (metres)	ELEVATION (metres above MSL)
#26 Colliery	-3300.1	7952.1	15
Lingan Airshaft	-8.6	2314.6	18
LRIS #1614	464.2	207.0	15
Low Pt. Light House	1850.9	-3282.6	9

2.4 CBCD Local Grid

The CBCD grid (or DEVCO grid) is the local grid used in the mining area. The grid origin is as follows:

CBCD Grid Origin:	Latitude:	46° 14' 59.05" N
	Longitude:	60° 05' 00.47" W

The grid is tied to the Nova Scotia geodetic network and utilizes the same parameters. The Nova Scotia geodetic grid is a Modified 3° Tranverse Mercator projection defined on the ATS77 ellipsoid.

Transformations from the CBCD grid to the Nova Scotia grid (or vice-versa) are available from the CBCD survey staff.

3.0 LINE COORDINATES

The following table lists the end coordinates of the 23 lines of the survey. The N and S at the end of the line name (see Enclosures 1 and 2) are North or South respectively indicating the direction that the line was surveyed. The annotation .1 or .2 at the end of the line indicate a reshoot or that the line was surveyed in 2 parts.

TABLE 2

LINE COORDINATES

LINE NAME	START OF LINE NORTHING (M)	START OF LINE EASTING (M)	END OF LINE NORTHING (M)	END OF LINE EASTING (M)	LENGTH (M)
8801	2100.0	1600.0	887.3	1296.8	1250.0
8802	2000.0	1800.0	890.5	1497.4	1150.0
8803	2000.0	2000.0	890.5	1697.4	1150.0
8804	2000.0	2200.0	793.5	1873.2	1250.0
8805	1900.0	2375.0	790.5	2072.4	1150.0
8806	1800.0	2540.0	690.5	2237.4	1150.0
8807	1800.0	2740.0	690.5	2437.4	1150.0
8808	1800.0	2940.0	592.2	2617.9	1250.0
8809	1280.0	1100.0	800.0	2920.0	1882.2
8810	1500.0	1100.0	970.0	3100.0	2069.0
8811	1700.0	1175.0	1173.4	3156.2	2050.0
8812	1940.0	1150.0	1355.0	3200.0	2131.8
8813	1500.0	4950.0	0.0	4800.0	1507.5
8814	1500.0	4150.0	0.0	4000.0	1507.5
8815	1500.0	3650.0	0.0	3500.0	1507.5
8816	1500.0	3900.0	0.0	3750.0	1507.5
8817	1500.0	4400.0	0.0	4250.0	1507.5

TABLE 2 CONT'D

LINE COORDINATES

LINE NAME	START OF LINE NORTHING (M)	START OF LINE EASTING (M)	END OF LINE NORTHING (M)	END OF LINE EASTING (M)	LENGTH (M)
8818	1500.0	4650.0	0.0	4500.0	1507.5
8819	1500.0	5150.0	0.0	5000.0	1507.5
8820	1500.0	5400.0	0.0	5250.0	1507.5
8821	1500.0	5650.0	0.0	5500.0	1507.5
8822	445.0	3000.0	280.0	5850.0	2854.0
8823	690.0	3000.0	520.0	6000.0	3004.8

The West Phalen site is composed of lines 8801 to 8808 in the north-south direction, and lines 8809 to 8812 in the east-west direction. The East Phalen site is composed of lines 8813 to 8821 in the north-south direction and lines 8822 and 8823 in the east-west direction.

4.0 CONCLUSIONS

Positioning accuracy through the entire survey was +/- 3 metres at the standard error ellipse confidence level. Residual signature and magnitude changed as the geometry changed through the survey. This puts in question the validity of the shore control coordinates or the Trisponder calibration values. The Trisponder equipment was calibrated prior to the survey and the calibration values were within 1 metre of those determined by the previous user of this equipment. A least squares calibration was done on the entire data set (i.e. positions recorded during the entire survey). It is suspected that station D, #26 Colliery, may have a coordinate error of +/- 5 metres. In a 4 range solution, the position would be altered by less than 2 to 3 metres if the correct coordinates were used.

Also, the only information received concerning the CBCD local grid was that the grid was tied to the Nova Scotia geodetic network and is defined similar to the LRIS grid. It would be valuable to obtain the exact parameters and particulars of this grid.

APPENDIX 5

LINE INVENTORY AND QUALITY SUMMARY

Date	Line	FSP	LSP	Local Time SOL	Local Time EOL	Conditions & Quality
Saturday	Bar check					
August 2	07S	Test Line			0922	
	7N	2046	2002	0940	0950	1 m Heave
	6S	2000	2046	0959	1009	
	6N		2000	1017	1028	
	9W	2000	2075	1047	1109	some pitching
	9E	2075	2000	1117	1130	vessel motion calmer
	10W	2000	2083	1139	1204	pitching, poor steering
	10E	2083	2002	1212	1228	sea astern
	11W	2000	2082	1236	1258	pitching
	8S				1345	aborted
	8S	2000	2050	1348	1358	seas calming
	8N	2050	2000	1402	1412	
	5S	2000	2046	1419	1430	1/2 - 1 m seas
	4N	2049	2000	1430	1444	
	3S	2000	2046	1449	1459	
	2N	2046	2000	1502	1511	
	1S	2000	2050	1518	1529	
	15N	2057	2000	1603	1616	
	16S	2000	2060	1622	1634	numerous course corrections
	14B	2061	2000	1638	1649	wind waves .25 m swell 0.5-1.0 m
	17S	2000	2061	1657	1710	
	18N	2060	2000	1713	1725	
	13N	2000		1731	1732	abort - wind 10-15
	13S	2000	2060	1737	1750	pitching ?
	19N	2060	2000	1755	1806	wind astern!
	20S	2000	2060	1812	1824	
	21N	2060	2000	1830	1842	
	22W	2115	2000	1903	1929	
	07.1N	2046	2000	1941	1950	sea relatively calm
	5.1S	2000	2046	1954	2006	wind light long swell ~1 m

Date	Line	FSP	LSP	Local Time SOL	Local Time EOL	Conditions & Quality
Saturday August 20	4.1N	2050	2002	2008	2018	
	3S	2000	2046	2029	2038	sea calm
	2.1N	2046	2000	2044	2053	
	1.1S	2000	2014	2057		aborted
	1.2S	2010	2050	2107	2115	
Sunday August 21	15S	2000	2060	0853	0905	sea calm with long swell
	16N	2060	2000	0908	0919E	
	14S	2000	2060	0924	0936	
	17N	2060	2000	0941	0953	
	18S	2000	2060	0957	1010	wind very light
	13N	2060	2000	1015	1528	wind very light long swell
	19S	2000	2060	1038	1049	
	20N	2060	2000	1055	1107	wind 5 kts.
	21S	2000	2060	1111	1122	
	23W	2000	2080	1133	1150	suspend line
	23.1W	2080	2120	1207	1215	
	8.1S	2000	2050	1256	1305	
	8.1N	2050	2000	1309	1320	
	7.1S	2000	2046	1324	1332	
	6.1N	2046	2000	1335	1345	
	6.1S	2000	2046	1347	1355	
	5.1N	2046	2000	1400	1409	wind 10-15 on starboard quick rolling
	4S	2000	2051	1413	1422	
	3N		2000	1425	1435	
	2S	2000	2045	1442	1452	broadside chop quick roll
	1N	2050	2000	1454	1505	
	11E	2000	2082	1515	1533	slight pitch
	12W	2085	2000	1536	1552	sea astern no pitching

End of Survey

MAPS
NOT
FILMED

CARTES
OMISES